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The Effect of Manual Guidance Upon Maze Learning

BY

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CONTENTS

CHAPTER I

INTRODUCTION

This investigation is concerned with the influence of manual guidance as a control upon learning. Human subjects were employed exclusively, and the problem selected was the mastery of a stylus maze. Learning directed by manual guidance, which is designated "controlled" learning, is contrasted with the free, undirected, trial and error type of learning, referred to as "normal." In the case of controlled learning, the experimenter guided the stylus in the subject's hand for a given number of trials over the correct pathway of the maze, thereby obviating all error possibilities. The procedure is practically identical with certain educational methods of instruction. For example, the teacher of writing or drawing may grasp the pupil's hand and forcefully initiate the proper movements. Tuition in various forms of needle-work, such as tatting, crocheting and knitting, is sometimes supplemented by manual guidance. The methods in vogue for teaching dancing and those occasionally employed in swimming and violin playing also suggest themselves as appropriate illustrations.

In the present study we have attempted to determine experimentally the following aspects of this problem:

1. *The effectiveness of manual guidance.* We sought to discover whether such guidance exerted a beneficial, negligible, or deleterious effect upon the learning of a maze.

2. *The relative effectiveness of the guidance.* Our concern was to determine whether a given number of controlled trials was more or less effective than an equal number of uncontrolled trials.

3. *The amount of guidance productive of optimum results.* We wished to know whether the effectiveness of the guidance increased in proportion to the amount given. Were eight guided trials productive of more beneficial results than four, and four than two?

4. *The position of the guidance in the learning from which op-*

timum results accrued. Whether guidance was more effective when given in the initial trials or interpolated at critical stages of the learning, was the problem investigated.

5. *The variation in effectiveness with different acts of motor skill.* We sought to determine whether the effectiveness of the guidance was a function of the particular act learned. Would the control exert a more beneficial effect upon one type of maze than upon another?

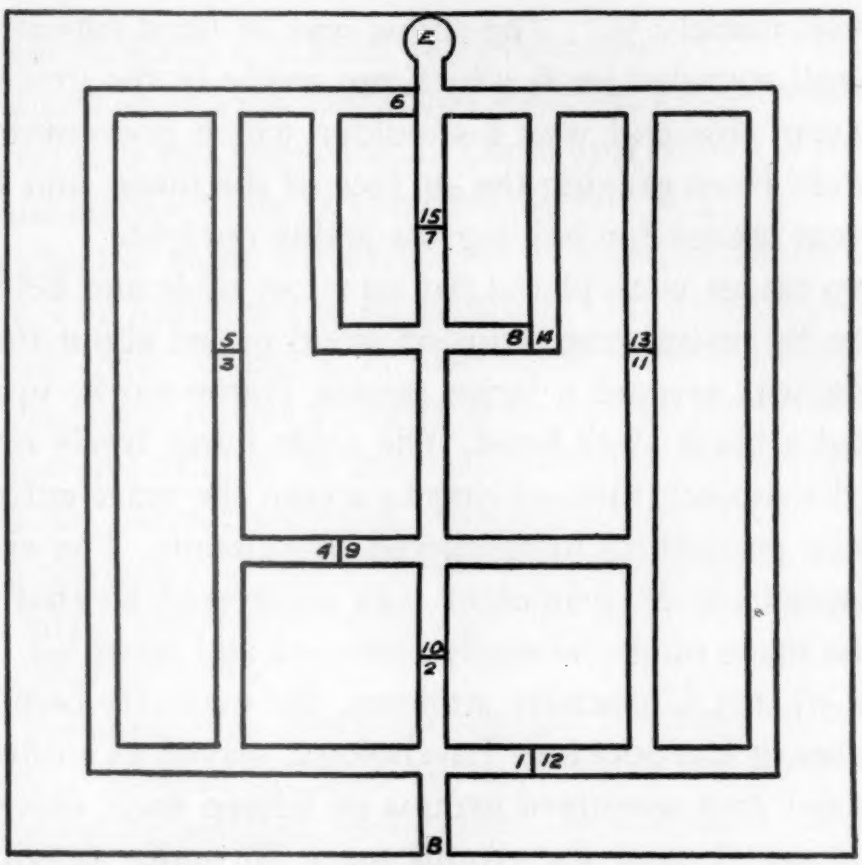
6. *The effect of guidance upon the mastery of subsequent acts of skill.* Our purpose was to learn whether subjects who mastered one maze under controlled conditions of learning would be at an advantage or a disadvantage in mastering a second maze, when their performance was compared with that of subjects who were uncontrolled in the former. In other words, would the amount of transfer be conditioned by the method of learning the first maze?

7. *Direct versus indirect effects of the guidance.* We wished to know what relations obtained between the influence of guidance upon a given maze and the influence through transfer upon that same maze, of guidance introduced in the learning of a previous maze.

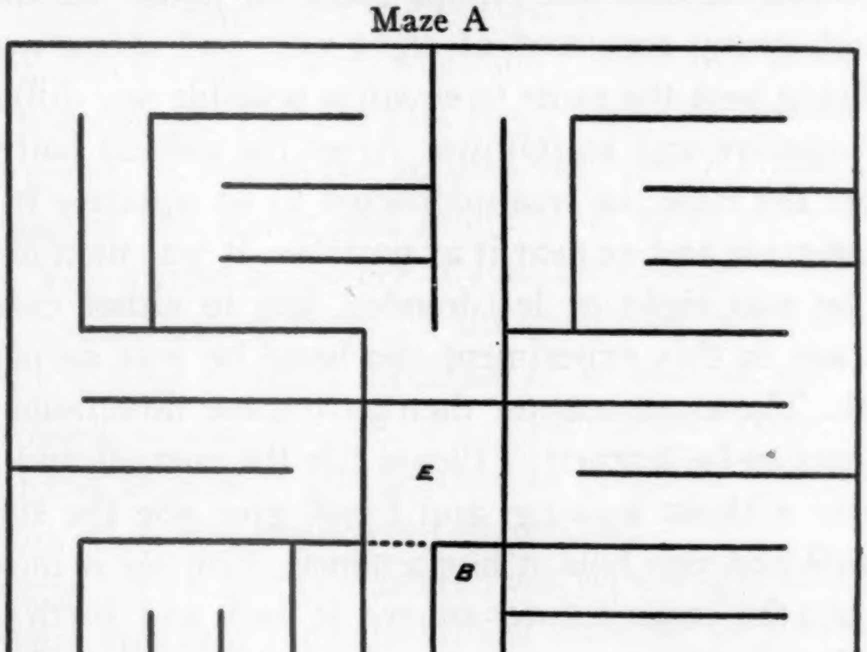
APPARATUS AND PROCEDURE

The two stylus mazes which were utilized differed in size, pattern, and construction. Maze A was the one employed by Professor Carr in his recent investigation of the influence of visual guidance in maze learning. Its dimensions were 16¼″ x 16½″. The pattern is represented in Figure I, where *B* designates the beginning and *E* the end of the pathway. The stylus consisted of a small circular brass disc on a vertical rod, which was attached to the hard rubber handle by a ball and socket joint. The maze was so constructed that the stylus could be lifted out of the grooves only at the two points *B* and *E*. At the completion of each trial, the experimenter removed it from the goal and replaced it at the beginning.

Maze B, the pattern of which is also represented in Figure I, was that employed by Pechstein in his investigation of whole vs. part methods in motor learning. The external dimensions were 5¼″ x 5¾″, and the walls were equal in thickness to the width of



Maze A



Maze B

FIGURE I

the grooves, namely ¼″. The stylus was of hard rubber provided with a small rounded knob which ran easily in the grooves. Half an inch from this end was a shoulder which prevented the subjects' fingers from grazing the surface of the maze, and furnished a convenient means for holding the stylus upright.

The two mazes were placed flat on a low table and held securely in position by restraining strips of wood nailed about them. Over each maze was erected a large square frame-work, upon which was tacked a black cloth hood. The folds hung freely on the side towards the subject, thus serving to screen the maze entirely from sight, while permitting unhampered movements. The side of the frame toward the experimenter was uncovered so that the mastery of the maze might be easily observed and recorded.

A total of 255 University students, the majority being selected from classes in Introductory Psychology, served as subjects. They were divided into seventeen groups of fifteen each, eleven groups learning maze A, and six groups maze B, under varying conditions. Each group consisted of eight men and seven women, the number being kept the same to equalize possible sex differences.

The procedure was as follows: After the subject had taken his seat before the table, he was instructed to sit squarely in front of the hooded maze and as near it as possible. It was next ascertained whether he was right or left-handed, but in either case he was asked to use in this experiment the hand he was accustomed to write with. The experimenter then gave these directions orally, if maze A was to be learned: "Please lift the curtain and put your hand under without looking, and I will give you the stylus. It is like a pencil and you hold it like a pencil. You see it moves along in grooves (the experimenter moved it back and forth) and you can't lift it out (the experimenter illustrated). There is only one place in the maze where you can lift it out, and the aim of the experiment is to keep moving the stylus about and exploring new pathways until you reach that place. You will know when you are there, but if you should not, I'll tell you. There is only one possible route and that is kept constant, but in addition to that there are a lot of blind alleys. The object is to learn to move the stylus over the true pathway without retracing and without entering any of

the blind alleys. Keep at it until you make four perfect records out of five trials. You can use any speed you like, but remember, speed does not count in this experiment. The whole object is to learn the maze in just as few trials as you possibly can."

Practically the same directions were given if maze B was to be learned. The difference in structure of the two mazes, however, necessitated these changes in the third and fourth sentences. . . . "You see it moves along in grooves and you must keep it *in* the grooves and hold it as erect as possible. (The experimenter illustrated the correct position.) Now the aim of the experiment is to keep moving the stylus about and exploring new pathways until you finally come to a larger open space. You will know when you reach that position," etc.

When guidance was given during the learning of a maze the experimenter grasped the base of the stylus below the point where it was held by the subject, and guided the subject's hand steadily, and at a uniform rate, over the correct pathway, thus preventing any errors. Each subject who was thus guided was given these additional directions: "For the first two times (the number varying with the group to which the subject belonged) I shall take hold of the base of the stylus and guide your hand over the correct pathway. You attend as closely as possible and get all the help you can." If, during any portion of the guidance, a tendency on the part of the subject to resist direction or to take an aggressive part in the movement was noticed, the experimenter requested him to keep his hand as passive and relaxed as possible. The maintenance of this condition was considered important.

In general the maze was mastered within a single sitting. Periods of rest were frequent throughout the learning to prevent fatigue, and it was no uncommon event for several such rests to occur during the first trial. In such a case, the subject renewed his attempts at the point where he left off. No schedule of rests was rigidly adhered to, however, because individuals differed in their susceptibility to fatigue, and the need appeared to depend upon the total distance traversed, which was subject to wide variations in each trial. The series of guided trials was given in uninterrupted sequence.

The experimenter recorded only the number of trials and errors, separating the latter into retracings and cul-de-sacs. Each section in the true pathway, however short or long, was considered a unit, which, when partially or wholly traversed in retracing, was counted one error. Entrance into a cul-de-sac was always counted as a cul-de-sac error, whether the direction of previous movement was toward the beginning or the goal. If the stylus was moved back and forth within one cul-de-sac, however, this was recorded as but one error. The criterion of mastery was four perfect records out of five successive attempts.

All experimentation was conducted in one room where approximately constant conditions were maintained. No testing was ever done with visitors present, and no interruption was permissible during the course of an experiment. The hours at which the experiments were given varied from 8 a.m. to 8 p.m., but care was taken to distribute the times fairly equally throughout the groups, in order that possible influence by factors of diurnal efficiency might be prevented. If, as frequently occurred, a subject failed to master the maze in one hour, he returned the next day or days at the same time and completed the learning.

CHAPTER II

THE EFFECT OF VARYING AMOUNTS OF INITIAL GUIDANCE

The object of the first experiment conducted was to determine the value of initial guidance in mastering maze A.

Six groups of fifteen subjects each were employed. In five groups the experimenter controlled the initial trials by guiding the stylus in the subject's hand, thereby rendering errors impossible, and permitting experience only with the pattern of the true pathway. These groups are, therefore, referred to as the "controlled" groups. One group was given this guidance the first two trials and the remainder of the learning was completed without aid. It was designated A 1-2. A second group was similarly guided the first four trials; a third, the first eight; a fourth, the first twelve, and a fifth, the first sixteen trials. These groups are designated A 1-4, A 1-8, A 1-12, and A 1-16 respectively, the A referring to the maze, and the figures to the number of guided trials given. Subsequent to the control, each subject completed the mastery of the problem without further aid. These records are compared with those of group A -0, which learned the maze entirely undirected, by the ordinary trial and error method, and is referred to as the "normal" group.

An analysis of these results may be conveniently made in three sections, concerned respectively with the following questions: I. "Was the guidance effective as a control, *i.e.,* did the subjects actually learn the maze in part during the controlled trials?" II. "Were the guided trials more or less efficacious than an equal number of unguided trials?" III. "What is the relative effectiveness of small versus large amounts of initial guidance?"

I. With respect to the first comparison, it is evident that if the control was entirely without effect, the number of trials and errors required to master the maze after the guidance should approximate that required by the normal group. Conversely, any decrease represented by the trial and error records of the controlled groups

relative to the normal group, would indicate its effectiveness. Table I presents the data on which the comparison is based.

TABLE I

Uncontrolled Trials and Errors in the Guided and Normal Groups

Group	Uncontrolled Trials	Errors		Percentages of Saving		
		Retracings	Cul-de-sacs	Trials	Retracings	Cul-de-sacs
A - 0	28.8 ± 8.0	74.1 ± 25.3	120.4 ± 45.3	..	..	..
A 1 - 2	21.2 ± 8.3	14.4 ± 12.2	39.0 ± 23.1	26	81	68
A 1 - 4	25.1 ± 11.2	23.1 ± 16.6	48.9 ± 36.3	13	69	59
A 1 - 8	19.5 ± 9.9	28.1 ± 20.8	41.7 ± 24.6	32	62	65
A 1 - 12	17.9 ± 5.9	10.9 ± 4.9	25.5 ± 11.1	39	85	79
A 1 - 16	25.1 ± 13.7	10.1 ± 7.2	33.1 ± 14.5	13	86	73

In the first column the number of initially guided trials are designated by the names of the groups. The second column, headed Uncontrolled Trials, represents the average number of trials required for completing the mastery of the maze subsequent to the guidance. The mean deviations of the trials for the various groups are given after these totals. No probable errors are included because these would be meaningless in groups of such small numbers. Under Errors appear the average number of retracing and cul-de-sac errors per individual and the mean deviations. The columns under the brace-heading Percentages of Saving represent the reductions made in trials and errors by the controlled groups relative to the normal group.

A comparison among the groups of the average errors per trial constitutes a further means of treating the data. Table II presents these results and the percentages of saving for each controlled group.

The figures in the second and third columns were obtained by dividing the average number of retracings and cul-de-sac errors by the average number of trials the group worked at the maze unaided, these data being supplied by Table I. The percentages of saving in the controlled groups were then computed.

The following conclusions are based upon the comparative data presented in these two tables.

TABLE II

Average Errors per Uncontrolled Trial in the Guided and Normal Groups

Group	Average Errors per Trial		Percentages of Saving	
	Retracings	Cul-de-sacs	Retracings	Cul-de-sacs
A 1 - 0	2.57	4.18	..	..
A 1 - 2	.68	1.84	74	56
A 1 - 4	.92	1.95	65	52
A 1 - 8	1.44	2.14	44	49
A 1 - 12	.61	1.42	76	66
A 1 - 16	.40	1.32	84	68

1. The guidance was decidedly efficacious. Since all controlled groups required fewer trials and errors to master the maze, it is evident that they completed a certain amount of the learning during the period of the control. The degree of mastery attained is represented by the percentages of saving in the last three columns of Table I. During its two controls, group A 1-2 mastered one-fourth of the maze (26%) with respect to trials, and approximately three-fourths (81% and 68%) with respect to the two types of error.

2. There is a tendency exhibited for the effectiveness of the guidance upon errors to vary directly with the amount given. Although the group given two guided trials represents an exception to this rule, the groups given larger amounts of control exhibit decreasingly fewer errors as compared with the records for the normal group. Upon trials, the effect of varying amounts of guidance is quite irregular.

3. Guidance does not exercise a similar effect upon both trials and errors. The decrease which it produces in errors exceeds by a large amount the decrease in trials. For example, in group A 1-8, the savings in errors (62% and 65%) are twice as large as the savings in trials (32%). In other words, the learning when measured by error elimination is greater than when measured by trial reduction.

4. Guidance produces an increase in variability with respect to trials and a decrease with respect to errors, as indicated by the mean deviations.

5. Guidance operates to produce large reductions in the average errors per trial, as is evident from the percentages of saving in Table II. For example, group A 1-4, which, subsequent to the control, required 25.1 trials to complete the mastery of the maze, made .92 retracing errors and 1.95 cul-de-sac errors per trial. These represent a decrease over the records of the normal group, and consequently a saving, of 65% and 52%, respectively. The largest number of controls is productive of the greatest savings.

The introspective accounts of the subjects support these conclusions. With but very few exceptions—and these chiefly poor subjects whose performance was inferior—there was unanimous agreement as to the aid afforded by the guidance. Individual reports varied with respect to the exact form this aid took. Some said the guidance enabled them to develop a visual image of the maze as a whole; others that it helped them at the beginning, the middle, or the end of the maze; still others, that it gave them a general idea of the direction of motion to be followed. Several declared that they had no visual imagery of the maze, but "had the feeling" where the stylus should move next. More sophisticated subjects reported kinaesthetic aid. Whether the guidance was utilized in terms of visual or kinaesthetic sensations, or images, or both, could not be determined by introspective accounts alone; but the fact that it appeared helpful is significant when taken in conjunction with the objective data.

To summarize, therefore, we find that manual guidance over the correct pathway during the initial trials of learning a stylus maze is effective as a control. All controlled groups attained a certain degree of mastery over the problem during the guidance. Subsequently they learned the maze in less trials with fewer total errors, and with reduced error records per trial than they would otherwise have done.

II. The relative efficacy of guided versus unguided trials may next be considered under the three following aspects: 1. "Granted that they learned the maze in part during the guidance, were the controlled groups superior or inferior to the normal group with respect to the total trial records?" 2. "Did they enter upon their self-initiated learning at a more or less advanced stage of error

elimination relative to the normal group at the corresponding point?" 3. "Did they maintain a higher or lower error record in subsequent trials than the normal group during the same period?" These questions may be answered by both tabular and graphical analyses.

1. The first question necessitates a comparison based upon the total number of trials, which, in the guided groups, includes the controlled as well as the uncontrolled trials. If a given number of initial guided trials was more effective than the same number of initial unguided trials in the normal group, it should be evident from a decreased number of total trials and errors. Table III presents the records for the total trials together with the percentages of saving and loss. Increase relative to the normal group—consequently loss—is indicated by a minus sign.

TABLE III

Total Trials in the Guided and Normal Groups

Group	Total Trials	Percentages of Saving and Loss
A - 0	28.8	...
A 1 - 2	23.2	19
A 1 - 4	29.1	— 1
A 1 - 8	27.5	5
A 1 - 12	29.9	— 4
A 1 - 16	41.1	—43

It is evident that group A 1-2 is the only one to manifest marked superiority over the normal group. The record for its total trials represents a saving of 19% over that of the normal group. Groups A 1-4, A 1-8, and A 1-12 are approximately equal to the normal group with respect to total trials, and group A 1-16 is decidedly inferior. Apparently then, so far as trials are concerned, two initial guided trials are more effective than the same number of unguided trials; and sixteen are considerably less effective than the same number of unguided trials.

No figures are presented for the average errors per trial, computed on the basis of the total trials. It was shown above that all the controlled groups learned the maze in part during the guided

trials. Moreover, since guidance prevented errors, and since savings were exhibited when the uncontrolled trials alone were utilized, as in Table II, it is obvious that even more marked savings result when the total trials are employed. The greater the number of trials, the smaller the average error per trial. From this aspect, then, all controlled groups are superior to the normal group.

2. The second topic—concerned with the question whether the controlled groups entered upon their undirected trials at a more or less advanced stage of the learning, relative to the normal group at the corresponding point—may be treated by a study of the learning curves. Typical curves are presented in Figure II for average retracing and cul-de-sac errors per trial. In each case the diagram for the controlled group is compared with that for the normal group.

It is evident that all guided groups began the learning after the controls at advanced stages, relative to the initial performance of the normal group. For example, the average number of cul-de-sac errors made in the initial trial by group A 1-4 was 5.3, as compared with 47.5 for group A -0.

On the other hand, when the performance of the controlled groups in the first trial after the guidance, is compared with that of the normal group for the corresponding trial, we find that all groups, save A 1-2, are at a less advanced stage of the learning. Whereas A 1-4 made 5.3 cul-de-sac errors in the fifth trial, group A -0 made only 3.1. Thus the initial errors of each controlled group are smaller than the initial errors of the normal group, but larger than the errors in the corresponding trial of the normal group. A 1-2 represents an exception to this statement.

3. The third topic—concerned with the question whether controlled groups maintained a higher or lower error record in subsequent trials than the normal group during the corresponding trials —may be answered partly by inspection of the curves and partly by a study of the comparative data presented in Table IV.

It was pointed out in a preceding paragraph that the curves of the controlled groups had their origin at higher levels than those of the normal curves for the corresponding trials. Attention must now be drawn to the fact that these curves do not maintain that higher level, but descend within a few trials, and thereafter closely

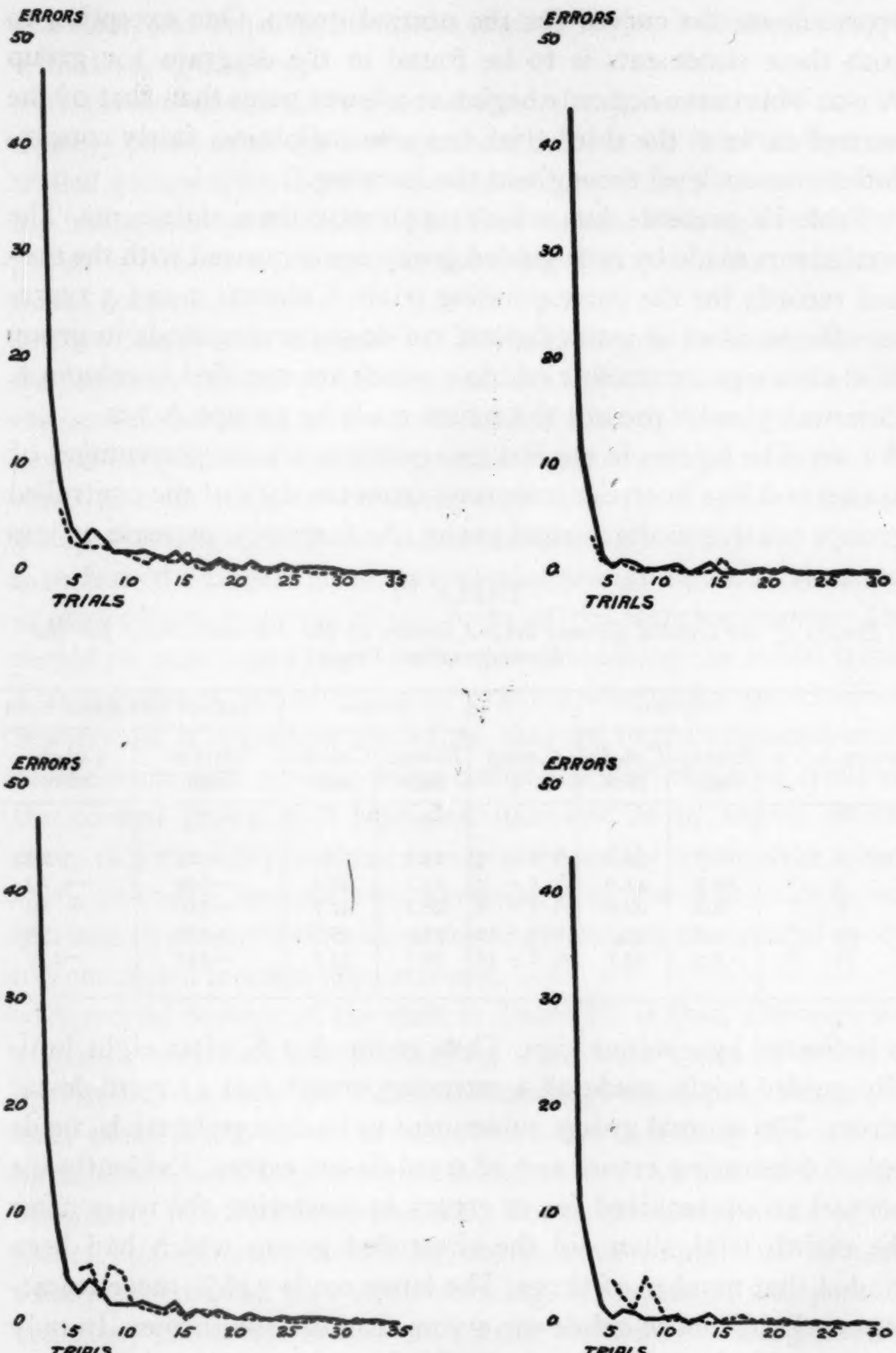


FIGURE II

Cul-de-sac Errors
Group A -0 ——
Group A 1-2 ....

Retracing Errors
Group A -0 ——
Group A 1-2 ....

Cul-de-sac Errors
Group A -0 ——
Group A 1-4 ....

Retracing Errors
Group A -0 ——
Group A 1-4 ....

approximate the curves for the normal group. One exception to both these statements is to be found in the diagram for group A 1-2. This curve not only begins at a lower point than that of the normal curve at the third trial, but also maintains, fairly consistently, a lower level throughout the learning.

Table IV presents data which supplement these statements. The total errors made by each guided group are compared with the normal records for the corresponding trials. Columns 2 and 3 represent the number of retracing and cul-de-sac errors made in group A -0 after a given number of trials which are specified in column 1. Columns 5 and 6 present the errors made by groups A 1-2 . . . A 1-16. The figures in the last two columns are the percentages of saving and loss in errors computed from the data of the controlled groups relative to the normal group. As formerly, increase or loss

TABLE IV

Errors of the Guided Groups versus Errors of the Normal Group for the Corresponding Trials

Group A - 0	Errors		Group	Errors		Pctg. of Sav'g and Loss	
	Retracings	Cul-de-sacs		Retracings	Cul-de-sacs	Retracings	Cul-de-sacs
After 2 trials	18.5	54.8	A 1 - 2	14.4	39.0	22	29
" 4 "	10.5	41.0	A 1 - 4	23.1	48.9	—120	— 19
" 8 "	6.6	28.0	A 1 - 8	28.1	41.7	—326	— 49
" 12 "	4.3	19.5	A 1 - 12	10.9	25.5	—150	— 31
" 16 "	2.4	13.1	A 1 - 16	10.1	33.1	—322	—152

is indicated by a minus sign. Thus group A 1-8, after eight initially guided trials, made 28.1 retracing errors and 41.7 cul-de-sac errors. The normal group, subsequent to its first eight trials, made only 6.6 retracing errors and 28.0 cul-de-sac errors. Evidently the normal group required fewer errors in mastering the maze after the eighth trial, than did the controlled group which had been guided that number of times. The latter made 326% more retracings and 49% more cul-de-sac errors than did the former. In only one controlled group, therefore, did the guidance exercise a beneficial effect upon succeeding trials. All other controlled groups made more errors while completing the problem subsequent to the

guidance, and hence maintained a slightly higher level as compared with the normal group.

A further comparison (for which the tabular data are not included) based upon the average error records per trial of the controlled groups with those of the normal group for the corresponding trials, is in conformity with these results. Here again the only group to exhibit a saving over the normal group is that with two initial controls.

Two features in the data of Table IV are to be noted. One is the tendency for the percentages of loss in errors to increase with the number of initial controls. Thus A 1-8, at the conclusion of its period of guidance, exhibits greater losses than A 1-4, when the error records of both are compared with those of the normal group. Although group A 1-12 forms an exception, group A 1-16 manifests the largest losses in errors of any group. This tendency is obviously a function of the form of the learning curves. The period of most rapid improvement occurs during the initial trials. The subsequent period is one of gradual elimination of relatively few errors. It is evident, therefore, that the initial unguided trials of the controlled groups, when compared with the later trials of the normal group, will represent increased error scores. Moreover, this disparity will become greater as the groups are given more guidance, because the effectiveness of the control does not increase in proportion to the amount given, and the normal group has continued to make improvement.

A second feature of the data in Table IV is that, although the guidance exercised a similar effect upon both types of error, it operated to increase the losses in retracings more proportionately than those in cul-de-sac errors. There are relatively few of the latter made, and they are eliminated sooner, as indicated in the diagrams. This fact is undoubtedly due to the construction of the maze. The distances were long, the pattern simple; and subjects soon realized when they were retracing. Moreover, it was possible for many cul-de-sac errors to be made without involving any retracings. Subjects showed a tendency to continue moving in the same direction until further progress was blocked. This procedure led them into blind alleys 6, 8, and 10 (Figure I), which were

almost invariably the last to be eliminated. Since the retracing errors were more rapidly reduced to a minimum in the normal curve, the initial uncontrolled trials of the guided groups necessarily represent a greater proportional increase with respect to this type of error than with respect to cul-de-sac errors.

We may conclude this section by the following summary. The group given two initial controls is the only one which attained a greater degree of mastery over the problem during its guided trials than the normal group during the same number of unguided trials. This fact is indicated by a smaller number of total trials, entrance upon the uncontrolled trials at a more advanced stage of the learning, and a consistently lower error record throughout the remainder of the learning as compared with the normal group.

III. The remaining question to be considered, namely: "What is the relative effectiveness of small versus large amounts of initial guidance?" requires only a brief summary and explanation, since it was treated in both the preceding discussions.

With respect to the number of uncontrolled trials, the effect of varying amounts of guidance was quite irregular; but with respect to the errors made in those trials, there was an indication that the effectiveness varied directly with the amount. On the other hand, where the total trials were compared, there was a marked tendency for the effectiveness of the control to vary inversely with the amount given. In addition, from the study of the errors by means of the graphical and tabular data, it was evident that the group with the fewest controls was the only one which was superior to the normal group in the period succeeding the guidance. The group with the largest number of controls was the most inferior in this respect. We may conclude, therefore, that within the limited number of controls investigated in the initial position, the efficacy of manual guidance tends to vary inversely with the amount given, the maximum effectiveness being produced by the minimum amount of guidance.

These tendencies are probably to be accounted for as follows: The guidance was instrumental in developing, within a few trials, an ideational knowledge of the correct pathway as a whole. This impression was comparatively vivid and clear-cut, since it was un-

complicated by errors, whereas the impression derived through self-directed activity during the same number of trials, was necessarily vague and confused, due to the occurrence of numerous cul-de-sac and retracing errors. Because of the large dimensions of the maze, the simplicity of the pattern, and the fact that bold sweeping movement were required, the utmost benefit could be derived from the control within two guided trials.

Greater amounts of guidance given initially not only imparted no additional benefit, but even were productive of detrimental consequences. These results are probably to be explained by certain habits and attitudes engendered in the subjects during the guidance, which were not conducive to the most efficient learning. For example, some subjects, because they were prevented from taking an aggressive part in the learning, lapsed into a passive attitude of dependence upon the experimenter, as contrasted with the active, self-reliant attitude which prevailed during undirected learning. When thrown upon their own resources in the trials subsequent to the guidance, therefore, these individuals, although they made fewer errors, nevertheless required as many or more trials than they would have otherwise, to complete the mastery of the maze. Moreover, inasmuch as the movements tended to become stereotyped and monotonous with repeated controls, and since none of the difficulties were experienced, other subjects grew convinced of the ease with which the problem could be mastered, and developed an attitude of over self-confidence. This also affected the subsequent period of the learning unfavorably. Finally, it is probable that the estimations of distances acquired passively through guidance, did not always coincide with those found necessary by later active explorations, and thus a confusing element was introduced through the control.

CHAPTER III

The Effect of Varying the Amount and Position of Interpolated Guidance

The preceding chapter presented evidence concerning the effectiveness of varying amounts of initial guidance in maze learning. The present chapter is concerned with an investigation of the effectiveness of varying amounts of this control interpolated at some intermediate position in the learning.

Inasmuch as two controls had proved to be the optimum amount of guidance introduced initially, we wished to determine the effect of that same amount inserted at various stages in the learning. In addition, we wished to ascertain whether a larger amount—*e.g.*, four guided trials, similarly introduced—would be more or less efficacious. Accordingly, the influence of these two amounts of guidance, each interpolated at various positions within the first twelve trials, was investigated experimentally.

The procedure was as follows: One group began to learn the maze according to the normal, undirected, trial and error method, but at the close of the second trial, the experimenter said to each subject: "For the next two trials, I shall take hold of the base of the stylus and guide your hand over the true pathway. You attend as closely as possible and get all the help you can." The subject's hand was then guided over the correct pathway for two consecutive trials. Subsequently each individual completed the mastery of the maze unaided. This group is referred to as A 3-4, since guidance was given during the third and fourth trials. Similarly, another group which commenced the learning in the normal manner was given guidance during the seventh and eighth trials (group A 7-8); and a third during the eleventh and twelfth trials (group A 11-12). Both groups then completed the learning without further aid.

The effect of four interpolated controls was tested in only two groups. In one, the guidance was introduced from the fifth to the

eighth trials inclusive (group A 5-8); and in the other, from the ninth to the twelfth trials inclusive (group A 9-12).

Discussion of these results may be divided into four sections, concerned respectively with the following questions: I. "Was interpolated guidance effective as a control, *i.e.*, did the subjects actually learn the maze in part during the guided trials?" II. "Were guided trials interpolated in the learning more or less efficacious than an equal number of corresponding unguided trials?" III. "What amount and position of interpolated guidance was productive of maximal effectiveness?" IV. "Was a given amount of interpolated guidance more or less efficacious than the same amount of initial guidance?"

I. The first question may be answered by an analysis of the comparative data presented in Tables V and VI. In Table V appears the average number of unguided trials required by each group to learn the maze, together with the average error records and the percentages of saving and loss due to guidance.

TABLE V

Uncontrolled Trials and Errors in the Guided and Normal Groups

Group	Uncontrolled Trials	Errors		Pctg. of Saving and Loss		
		Retracings	Cul-de-sacs	Trials	Retracings	Cul-de-sacs
A - 0	28.8 ± 8.0	74.1 ± 25.3	120.4 ± 45.3	..	..	..
A 3 - 4	17.1 ± 3.1	64.9 ± 23.1	99.6 ± 44.5	41	12	17
A 5 - 8	20.9 ± 7.2	48.0 ± 37.8	97.5 ± 65.6	27	35	19
A 7 - 8	22.3 ± 8.3	64.6 ± 34.6	108.8 ± 62.7	23	13	10
A 9 - 12	24.6 ± 4.4	86.7 ± 30.1	121.3 ± 39.8	15	—17	— 1
All - 12	28.1 ± 8.2	113.3 ± 61.1	160.5 ± 34.5	2	—53	—33

The average errors per unguided trial for the various groups are presented in the second and third columns of Table VI. These were computed from the data of Table V. In addition the percentages of saving and loss with respect to both types of error are supplied by columns 4 and 5.

In these data the following tendencies are manifested:

1. Guidance interpolated at various positions in the learning exercises a beneficial effect upon total trials and errors. During the

TABLE VI

Average Errors per Unguided Trial in the Guided and Normal Groups

Group	Average Errors per Trial		Percentages of Saving and Loss	
	Retracings	Cul-de-sacs	Retracings	Cul-de-sacs
A - 0	2.57	4.18	....	....
A 3 - 4	3.79	5.82	—48	—39
A 5 - 8	2.30	4.67	11	—10
A 7 - 8	2.90	4.88	—13	—17
A 9 - 12	3.52	4.93	—37	—18
A 11 - 12	4.03	5.71	—57	—37

guidance all groups completed a portion of the learning, the specific amounts being represented by the percentages of gain relative to the normal group. Thus group A 3-4 saved 41% in trials, and 12% and 17% in retracing and cul-de-sac errors respectively. Exceptions to this tendency are found in the average error records of two groups. When the control was inserted during the third four trials, it produced increased error records relative to the normal group.

2. There is a tendency for the effectiveness of the guidance, as measured by total trials and errors, to vary with position. The beneficial influence of the control decreases in proportion to the distance from the beginning at which it is introduced. Thus the largest savings in trials are made by the group given the earliest interpolated guidance (group A 3-4); smaller savings by those groups guided within the next series of trials (groups A 5-8 and A 7-8); and the least savings by those groups given guidance during the succeeding series of trials (groups A 9-12 and A 11-12). The tendency is not so apparent with respect to average errors, although those groups in the later stages of whose learning the guidance was introduced, exhibit excessive amounts of error.

3. Guidance does not exercise the same degree of effect upon both trials and errors. So far as savings are concerned, with but one exception (group A 5-8) and for one type of error, the guidance exercised a greater effect upon trials than upon errors. This is the explanation for the increased average errors per trial in the controlled groups, as shown in Table VI. Obviously, division of

the total errors by decreased numbers of trials will produce increased error scores.

4. Guidance produces a decrease in variability with respect to trials, and an increase in variability with respect to errors save for a few exceptions.

II. We shall next consider the relative effectiveness of guided trials, introduced at various stages in the learning, as compared with the corresponding unguided trials. Did the subjects attain a greater degree of mastery over the problem from the control than they would have by their self-directed activity? If so, this fact should be indicated by (1) fewer total trials, and (2) decreased error records throughout the remainder of the learning.

1. The first criterion may be discussed in connection with the data of Table VII. The total trials for each group are presented, and the records for the controlled groups are expressed in percentages of saving and loss with respect to the normal record.

It is evident that all groups save one were superior in total trials to the normal group. The group given two interpolated controls during the third and fourth trials was enabled to complete the learning in two-thirds the number of trials required by the unguided group. Groups A 7-8 and A 5-8, given two and four controls respectively, during the second four trials, saved approximately one-seventh of the trials required by the normal group.

TABLE VII

Total Trials in the Guided and Normal Groups

Group	Total Trials	Percentages of Saving and Loss
A - 0	28.8	..
A 3 - 4	19.1	34
A 5 - 8	24.9	14
A 7 - 8	24.3	16
A 9 - 12	28.6	1
A 11 - 12	30.1	— 5

Those groups whose guidance was inserted in the third four trials required practically the same number of trials to master the maze

as the normal group. Again the tendency is noticeable for the effectiveness of the guidance to vary with position. Guided trials, therefore, are more effective, with but one exception, than unguided trials.

2. The second criterion of the efficacy of the guidance is the maintenance of reduced error records throughout the remainder of the learning. We may make two comparisons between the controlled and the normal groups with respect to the error scores, the first based upon those made in the five trials immediately following the guidance, and the second based upon those made in the total trials subsequent to the guidance.

Table VIII presents the data for the first comparison. Columns 2 and 3 present the average retracings and cul-de-sac errors made by group A -o during the separate series of five trials each, speci-

TABLE VIII

Errors for Five Trials Succeeding Guidance in Controlled Groups Versus Corresponding Errors in the Normal Group

Group A - o	Errors		Group	Errors	
	Retrac-ings	Cul-de-sacs		Retrac-ings	Cul-de-sacs
Trials 5- 9	4.5	15.1	A 3 - 4	3.7	12.5
" 9-13	2.9	10.9	A 7 - 8	10.7[2.3]	17.6[7.9]
" 13-17	2.1	7.2	A 11 - 12	3.1	8.1
" 9-13	2.9	10.9	A 5 - 8	3.6	8.7
" 13-17	2.1	7.2	A 9 - 12	1.4	7.5

fied in column 1. The errors made by the controlled groups in the corresponding trials, which are in every case those trials immediately following the guidance, appear in column 5 and 6.

In Table IX the error records made by each controlled group during the entire period of the learning subsequent to the guidance are compared with those of the normal group for the corresponding trials. Columns 2 and 3 represent the number of retracing and cul-de-sac errors made in group A -o after a given number of trials which are designated in column 1. Columns 5 and 6 present the errors made by the controlled groups in the corresponding period. The figures in the last two columns are the percentages of

TABLE IX

Errors of the Controlled Groups for the Entire Period Succeding Guidance Versus Corresponding Errors of the Normal Group

Group A - o	Errors		Group	Errors		Pctg. of Sav'g and Loss	
	Retracings	Cul-de-sacs		Retracings	Cul-de-sacs	Retracings	Cul-de-sacs
After 4 trials	10.5	41.0	A 3 - 4	7.9	22.8	25	44
" 8 "	6.6	28.0	A 7 - 8	13.9	30.9	—111	—10
" 12 "	4.3	19.5	A 11 - 12	11.6	23.7	—170	—22
" 8 "	6.6	28.0	A 5 - 8	7.2	22.2	— 9	21
" 12 "	4.3	19.5	A 9 - 12	5.6	18.8	— 30	4

saving and loss in errors for the controlled groups relative to the normal group.

In these comparative data the following features are to be noted.

1. With respect to the effects of the control in the period immediately following, we find that one group alone began the subsequent learning at a more advanced stage of error elimination than did the normal group. Group A 3-4 made only 3.7 retracings and 12.5 cul-de-sac errors during the fifth to ninth trials which succeeded its guidance, whereas the normal group made 4.5 and 15.1 respectively.

Group A 7-8 apparently entered upon its subsequent learning at a less advanced stage. The largely increased error scores, however, are caused solely by one poor record. This subject made 44 retracing errors and 71 cul-de-sac errors in the ninth trial, when the next highest scores were 1 and 4 errors respectively; and he maintained this high record for several trials. The figures in brackets, therefore, indicate the average errors computed for the 14 remaining subjects of the group. The majority of individuals of this group also resumed the learning at a more advanced stage than did the normal group.

Group A 11-12 began the learning subsequent to the guidance at a less advanced stage with respect to both types of error, as also did group A 5-8 with respect to retracings, and A 9-12 with respect to cul-de-sac errors.

2. In regard to the influence of the control upon the entire remaining period of the learning, we find again that only one group

(A 3-4) maintained a consistently lower level subsequent to the guidance than that of the normal group.

Groups A 5-8 and A 9-12 exhibit fewer cul-de-sac errors during the remainder of the learning, and hence maintained a slightly lower level in this respect.

Groups A 7-8 and A 11-12 required increased amounts of error throughout the subsequent learning.

3. The control exercises a more beneficial effect upon cul-de-sac errors than upon retracing errors during the total period subsequent to the guidance. The greatest savings and the least losses are found in the case of the former type of error.

4. There is in the data of Table IX the same tendency previously noted, for the guidance to exert less beneficial influence upon error elimination in proportion to the distance from the beginning at which it is introduced. Thus two controls interpolated very early in the learning are decidedly effective; two given during the seventh and eighth trials are detrimental; but two controls inserted at the eleventh and twelfth trials are even more detrimental. The same tendency is evident in the case of four controls in the two different positions.

5. The effectiveness of the guidance, as indicated by the error elimination throughout the remainder of the learning varies directly with the amount given. Four interpolated controls are productive of decreased cul-de-sac errors and smaller increases in retracings than are two controls in the corresponding stages of the learning.

That the differences between these groups are due largely to the effects of the guidance and not to chance or group differences in ability, has been assumed in the preceding discussions. The validity of this assumption may be established by a comparison between the initial efforts of the various groups. Since each controlled group began learning the maze according to the normal, undirected, trial and error method, the records of all trials preceding the guidance are comparable to those of the normal group. These data are given in Table X.

Inspection of this table reveals the close correspondence existing between groups at the outset. For example group A 9-12 made

TABLE X

Errors in the Initial Trials of Groups Given Interpolated Guidance Versus the Corresponding Errors of the Normal Group

Group A - 0	Errors		Group	Errors	
	Retracings	Cul-de-sacs		Retracings	Cul-de-sacs
Trials 1 - 2	27.8	32.8	A 3 - 4	28.5	38.4
" 1 - 6	10.9	14.5	A 7 - 8	8.4	13.0
" 1 - 10	6.9	9.7	A 11 - 12	10.2	13.6
" 1 - 4	15.9	19.9	A 5 - 8	11.2	20.2
" 1 - 8	8.4	11.6	A 9 - 12	9.5	11.9

9.5 retracings and 11.9 cul-de-sac errors during the first eight trials, while the normal group made 8.4 and 11.6 respectively. Perhaps the greatest disparity occurs between group A 3-4 and the normal group. The former made 38.4 cul-de-sac errors during the first two trials, and the latter 32.8. The advantage, however, lies wholly with the normal group, yet in this case the control was extremely effective. Finally, there is no correlation evident between the initial error records of the various groups and the effectiveness of the guidance in the subsequent period of the learning.

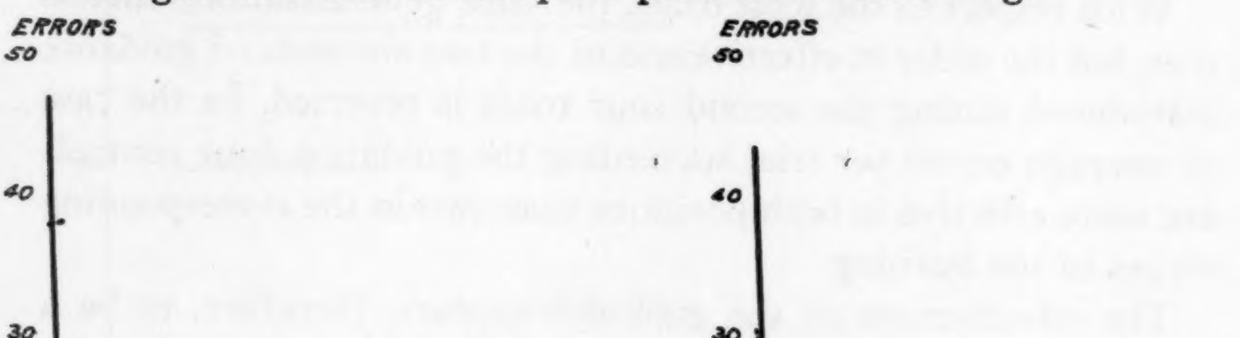


FIGURE III

Cul-de-sac Errors
Group A - 0 ——
Group A 3 - 4 ....

Retracing Errors
Group A - 0 ——
Group A 3 - 4 ....

The learning curves for all the controlled groups illustrate the facts which have been discussed in connection with the tabular data, but since the latter constitute a more condensed form of presentation, they have been employed exclusively. One set of curves, however, may be included—that of group A 3-4 in Figure III. The large initial error scores, and the reduced amount of errors throughout the period of the learning subsequent to the guidance, are the significant features.

III. The third question to be considered, namely: "What amount and position of interpolated guidance is productive of maximum effectiveness?" has been dealt with under several aspects in the preceding sections, but requires a brief résumé.

With respect to the number of uncontrolled trials, two controls introduced during the third and fourth trials are most effective; four and two controls, in decreasing order, given during the second four trials, are somewhat less so; while four and two controls during the third four trials are least effective. A similar tendency appears in the error records, but in this case guidance interpolated late in the learning actually exercises a deleterious influence.

With respect to the total trials, the same generalization remains true, but the order in effectiveness of the two amounts of guidance introduced during the second four trials is reversed. In the case of average errors per trial succeeding the guidance, four controls are more effective in both positions than two in the corresponding stages of the learning.

The effectiveness of the guidance appears, therefore, to be a function of both position and amount. Within the limited number of positions investigated, there is a marked tendency for the effectiveness of the guidance to increase in proportion to its proximity to the initial attempts. Evidence for this fact is furnished by total trials and errors, as well as average errors per trial.

Within the limited number of controls investigated, the larger amount is more effective in each position according to the criteria of uncontrolled trials, total errors and average errors per trial in subsequent learning. According to the criterion of total trials, the averages are not consistently in favor of either amount, but the medians, as illustrated in Figure IV, indicate that the smaller

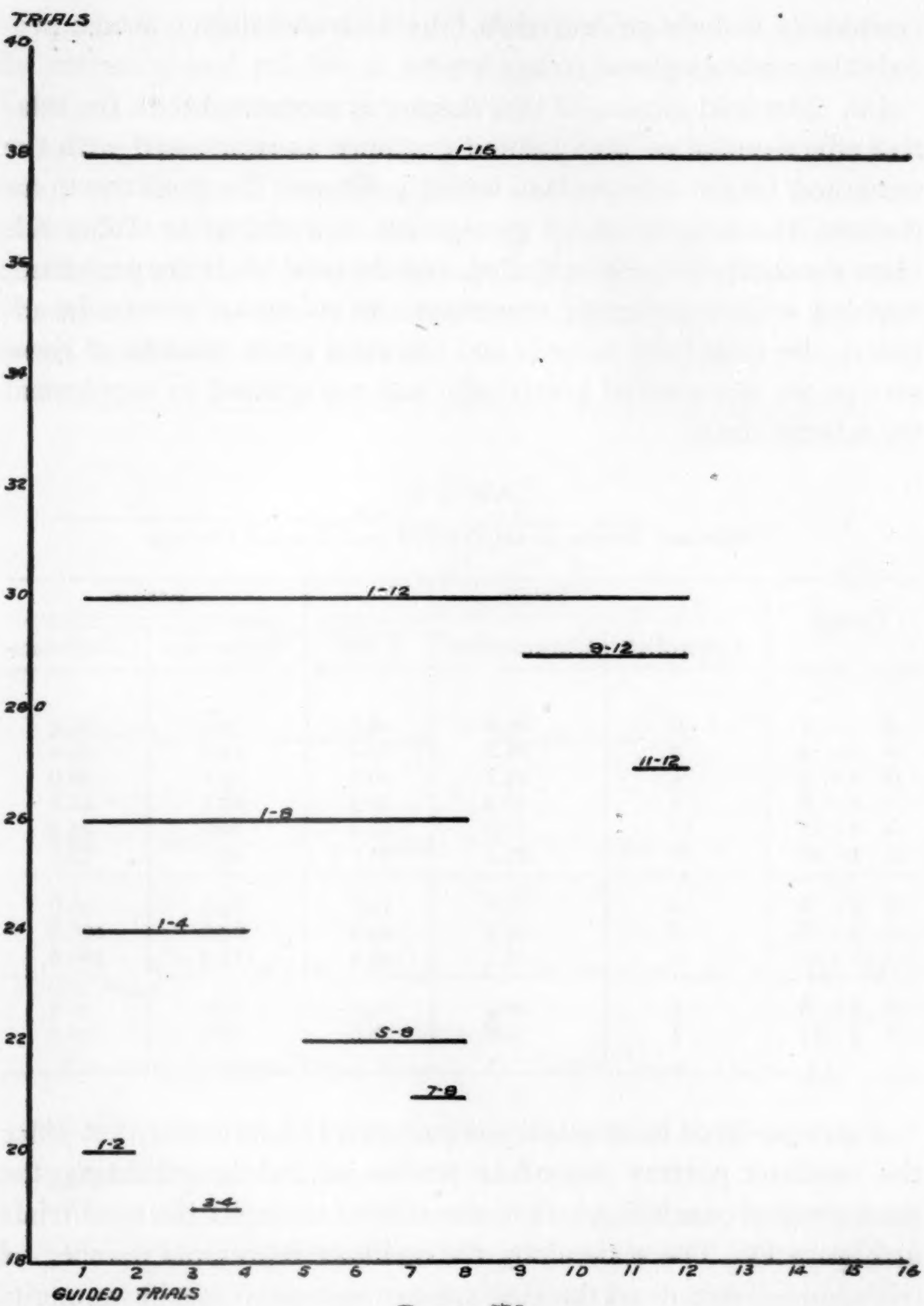


FIGURE IV
Median Number of Total Trials Required by Guided Groups (Maze A)

amount is more effective in each position. These features, however, are probably a function not wholly of amount, but partially, at least, of position. For example, the four controls of group A 5-8

necessarily include guided trials (the fifth and sixth), which precede the controls given group A 7-8.

IV. The final section of this chapter is concerned with the relative effectiveness of interpolated guidance as contrasted with the same and larger amounts of initial guidance. To facilitate comparison, the records of all groups are reproduced in Table XI. Here the controlled, uncontrolled, and the total trials are presented, together with the average retracings and cul-de-sac errors. In addition, the total trial records and the total error records of these groups are represented graphically and are utilized to supplement the tabular data.

TABLE XI

Trials and Errors in the Guided and Normal Groups

Group	Trials			Errors	
	Controlled	Uncontrolled	Total	Retracings	Cul-de-sacs
A - 0	0	28.8	28.8	74.1	120.4
A 1 - 2	2	21.2	23.2	14.4	39.0
A 1 - 4	4	25.1	29.1	23.1	48.9
A 1 - 8	8	19.5	27.5	28.1	41.7
A 1 - 12	12	17.9	29.9	10.9	25.5
A 1 - 16	16	25.1	41.1	10.1	33.1
A 3 - 4	2	17.1	19.1	64.9	99.6
A 7 - 8	2	22.3	24.3	64.6	108.8
A 11 - 12	2	28.1	30.1	113.3	160.5
A 5 - 8	4	20.9	24.9	48.0	97.5
A 9 - 12	4	24.6	28.6	86.7	121.3

Averages have been employed exclusively heretofore, but since the medians portray smoother tendencies, while indicating the same general conclusions, they are utilized to depict the total trials in Figure IV. The scale along the ordinate represents number of trials, and distances on the abscissa correspond to specific amounts and positions of guidance. For example, the line of twelve units, connecting the first and the twelfth guided trials, refers to group A 1-12, and its position indicates that this group required 30 trials to master the maze. The normal group, which required 28 trials, is represented by the point at zero guided trials.

The combined error records of all groups, computed by adding the retracing and cul-de-sac errors given in columns 5 and 6 of Table XI are represented graphically in Figure V. Since the numbers along the abscissa represent guided trials, each line designates one group by specifying the amount and position of the guidance given. Thus the line two units long, connecting the third and fourth guided trials, refers to group A 3-4. The figures above each line represent the number of errors made by that group; A 3-4, for example, making 164.5 errors.

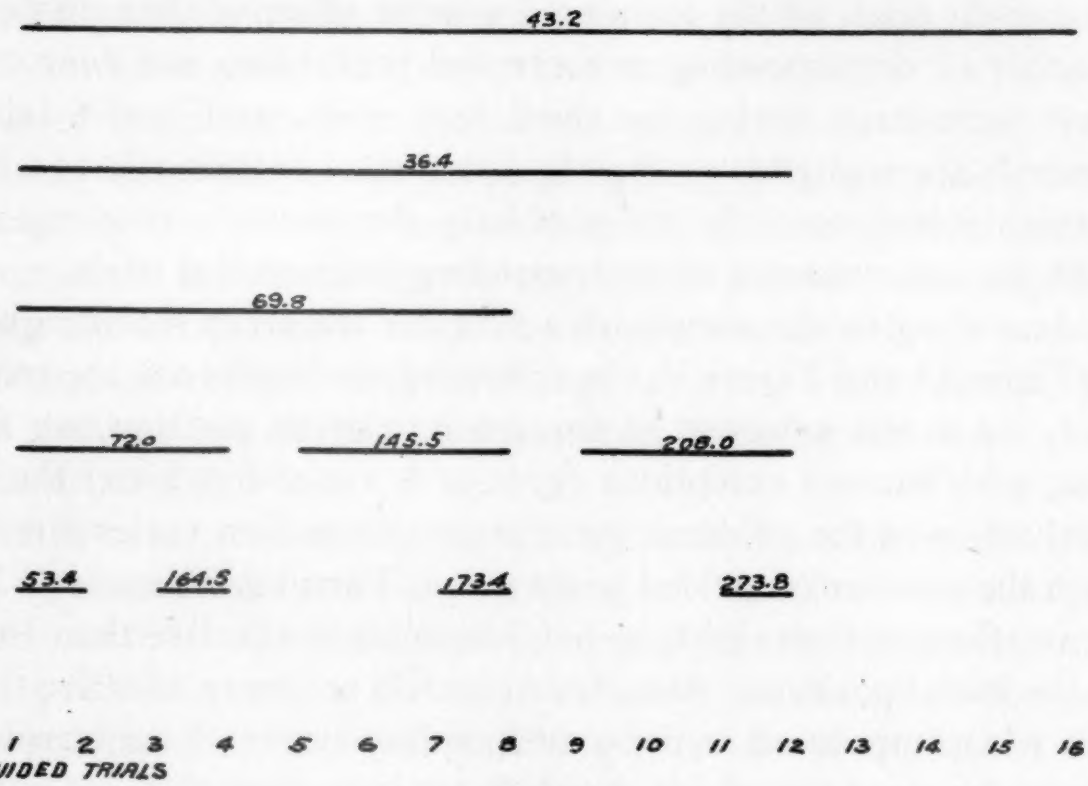


FIGURE V
Combined Average Error Records of Guided Groups (Maze A)

The following are the outstanding features in both the tabular and graphical presentations of the total trials.

1. As to the influence of the amount of guidance, it is evident that, for a given position, the smaller the number of guided trials, the more beneficial are the results. Thus if the initial learning be divided into three stages of four trials each, two controls are more effective than four in each stage; four controls in either of the first two stages are more effective than eight, and in the third stage more effective than twelve. Finally, eight initial controls are more effective than twelve, and twelve than sixteen.

2. The influence of position, when the amount is kept constant, is as follows: Guidance introduced at an early stage in the learning exerts a more beneficial influence than when introduced initially, but when it is interpolated at an advanced stage in the learning, there is a decrease in beneficial consequences. Thus the maximum effectiveness from two controls is attained by their introduction in the third and fourth trials, and from four controls, by their interpolation during the fifth to eighth trials.

3. Two, four, and eight controls inserted at any position in the first eight trials of the learning are more effective than an equal number of corresponding uncontrolled trials; two and four controls introduced during the third four trials, and twelve initial controls are negligible or slightly detrimental in their effect; while sixteen initial controls are positively detrimental, as compared with the same number of corresponding uncontrolled trials.

According to the comparative data for the error records given in Table XI and Figure V, the following tendencies are apparent:

1. As to the influence of amount in a given position, we find that, with but two exceptions (groups A 1-2 and A 1-12) the effectiveness of the guidance upon error elimination varies directly with the number of guided trials given. Thus twelve controls are more effective than eight, and eight are more effective than four, in the initial positions. Also, four controls are more effective than two when introduced in the corresponding stages of the learning. Again the error record for group A 1-2 is an exception.

2. As to the influence of position, a uniform tendency is apparent for each of the two amounts investigated. The effectiveness varies directly with proximity to the initial trials. Thus the error record of group A 1-2 is less than that of group A 3-4; that of the latter is less than the error record for group A 7-8, which in turn is less than that of group A 11-12.

3. Since the combined errors for the normal group, which are not represented in Figure V, total 194.5, it is evident that each number and position of guided trials—save two and four, introduced during the third four trials—are more effective upon errors than the same number of corresponding unguided trials.

The above factual conclusions derived from our comparative

data can be explained by the supposition that guidance exerts both a favorable and a detrimental influence, the relative proportion of the two varying with position and amount.

The advantageous effects may be summarized in the following statements: Presumably, guidance operates to impart, within a few trials, a comparatively clear impression of the true pathway as a whole, entirely free from errors. Less benefit is derived when it is introduced initially than when it is inserted after a few preliminary undirected trials. The subjects have then acquired a general knowledge of the maze, but the conception of the correct route to be followed is necessarily vague and indefinite, due to the occurrence of complicating erroneous movements. This confused impression is clarified by the guidance, which, by deleting all errors, throws the true pathway into bold relief, and the subjects' interpretation is facilitated by the previously acquired apperceptive background. Obviously, when the guidance is introduced during later and later stages of the learning, when the knowledge of the true pathway has already been acquired, the beneficial results become decreasingly less.

Furthermore, when the subjects begin the learning by the trial and error method, there is a prevailing tendency for certain errors to become fixed and established as integral parts of the act learned. The guidance exerts a favorable influence insofar as it disrupts this process of error fixation. The greater the amount, and the earlier the introduction of the guidance, the more successfully will it overcome this habit; and conversely, the smaller the amount, and the later the introduction, the less will be the counteracting effect.

Moreover, it is probable, on *a priori* grounds, that a greater number of controls are necessary to procure the maximum effectiveness in the case of an early introduction, where there is much to be learned, than in the case of a later introduction. Consequently we should expect to secure the utmost benefit from the tuition by a larger number of guided trials in the early stages and by a decreasing number in the later stages. Doubtless the same advantage would have accrued from one guided trial introduced at an intermediate stage of the learning, as from two guided trials introduced at an earlier stage.

Guidance also exerts a detrimental effect, the degree of which varies with position and amount. It disrupts helpful associative connections formed between sensory cues in the maze and specific modes of reaction. Early in the mastery of the maze, subjects developed such habits as pressing the stylus against one side of a groove to escape a cul-de-sac, feeling for the absence of a resisting wall to indicate another, or counting openings in order to avoid a third. The experimenter's manipulation of the stylus necessarily did not duplicate the subject's previous types of activity, and the guidance therefore exercised a deleterious influence. Presumably this effect will vary directly with the amount of guidance. Also, the later the introduction of the tuition, the more fixed will be the former system of habits, and the less disadvantageous will be the consequences. The earlier the interpolation and the larger the amount, the greater will be the disruptive effect.

In addition to breaking old habits, guidance may establish new habits, and mental and motor attitudes toward the problem, which will carry over and affect the subsequent learning detrimentally. For example, it is probable that the estimations of distances, which are acquired during tuition, will not coincide with those subsequently found necessary in self-directed activity. Also the control may generate attitudes of over self-confidence or of dependence upon the experimenter, either of which will be unfavorable to the learning. So far as this influence is concerned, the greater the amount of guidance, the greater the deleterious effect. Doubtless it varies with position also, the detrimental consequences decreasing according as the control is interpolated later and later in the learning.

The fact that guidance exerted a different effect upon trials and errors, is probably to be accounted for in the following manner: The mere physical fact of error prevention operates to reduce errors decidedly more than trials. The greater the amount of guidance and the earlier the introduction, the more efficacious will be the control in eliminating errors. Conversely, the smaller the amount and the later the introduction, the less will be the beneficial consequences in this respect.

Furthermore, it is probable that the advantageous and disad-

vantageous aspects of the guidance, previously enumerated, affect one criterion of mastery more than the other. For example, when the clear conception of the true pathway was imparted by the guidance after certain errors had become established as integral parts of the reaction, a conflict ensued in the subsequent trials. Subjects apparently had correct conceptions, because, frequently, in the very act of traversing a cul-de-sac, an individual would realize suddenly that an error was being made and return immediately to the true pathway. Presumably the habitual mode of reaction was asserting itself despite the knowledge of the correct reaction. Such a performance increased the error records considerably, but after a certain number of repetitions, the subjects were enabled successfully to anticipate the cul-de-sacs; the knowledge of the true pathway predominated; and as a result the total trials were decidedly reduced.

On the other hand, certain habits acquired during the period of the guidance probably exerted a more detrimental effect upon trials than upon error records. For example, the attitude of over self-confidence, which frequently appeared after large amounts of initial guidance had been given, was not conducive to cautious explorations in the subsequent trials. Because of their familiarity with the true pathway and their ignorance of all error possibilities, so simple did the subjects conceive the problem to be, and so positive were they of their ability to make a perfect record, that they proceeded thoughtlessly and without heed, trial after trial. Comparatively few errors were made, but large numbers of trials were required before the maze was mastered.

CHAPTER IV

THE EFFECT OF MANUAL GUIDANCE UPON THE LEARNING OF MAZE B

The influence of initial and interpolated guidance upon the learning of one maze was determined in the preceding chapters. Within the limits of the investigation, minimum amounts of control, introduced very early in the learning, were productive of maximal effectiveness. The question then arises as to whether these results are specific and limited only to one maze, or whether they are applicable to mazes in general.

For the investigation of this problem, a second maze was utilized, which is designated maze B. From the representation of its pattern in Figure I, and the description of its structure in Chapter I, it is apparent that, with respect to size, length and number of sections, direction of successive movements and kind of stylus employed, this maze constitutes a materially different problem from that of maze A.

Six groups of fifteen subjects each were employed, and certain of the previous conditions of the learning were duplicated. One group mastered the maze according to the free, undirected, trial and error method, and consequently is referred to as B -0. Three groups were given initial guidance. One was controlled the first four trials and is designated B 1-4; another was controlled the first eight trials (B 1-8); and a third, the first twelve trials (B 1-12). Two groups were given interpolated guidance. Four controls were introduced during the fifth to eighth trials in one group (B 5-8); and during the ninth to twelfth trials in another group (B 9-12). Subsequent to the guidance all controlled groups completed the mastery of the maze unaided.

Discussion of the results of these experiments will be limited to the aspects involved in the following three questions: I "What were the effects of varying amounts and positions of guidance upon the learning of maze B?" II. "What were the differences in

the results obtained from maze B as compared with the results obtained from maze A?" III. "What are the explanations for these differences in results in the two mazes?"

I. The first question may be answered by an analysis of the comparative data, presented in both tabular and graphical form. In Table XII appear the controlled, uncontrolled, and total trials required by all groups, together with the total errors. In addition, the total trials and the total errors are represented in Figures VI and VII respectively.

In Figure VI each line refers to a particular group, by designating the amount and position of its guidance. The location of each line with reference to the ordinate indicates the total trials required by that group. Thus group B 1-12 required 22.5 trials. The normal group is represented by the point at zero guided trials, the position of which indicates that it required 29.2 trials.

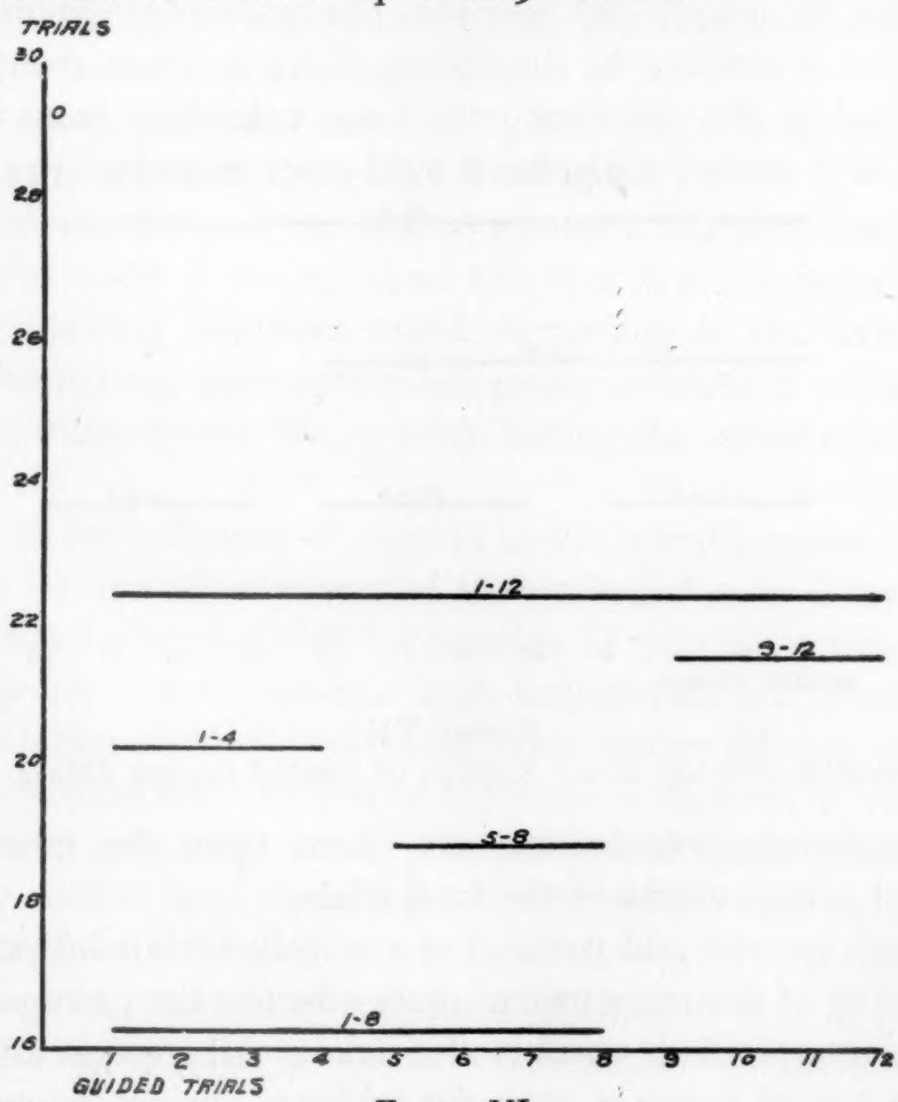


FIGURE VI
Average Number of Total Trials Required by Guided Groups (Maze B)

TABLE XII

Trials and Errors in the Guided and Normal Groups

Group	Trials			Errors	
	Controlled	Uncontrolled	Total	Retracings	Cul-de-sacs
B - 0	0	29.2 ± 11.6	29.2	362.8 ± 80.5	73.6 ± 44.7
B 1 - 4	4	16.3 ± 9.3	20.3	113.9 ± 98.4	20.5 ± 15.1
B 1 - 8	8	8.3 ± 3.6	16.3	17.9 ± 14.5	4.9 ± 4.5
B 1 - 12	12	10.5 ± 4.7	22.5	40.4 ± 37.7	11.5 ± 9.0
B 5 - 8	4	14.9 ± 5.2	18.9	246.3 ± 120.3	25.7 ± 15.0
B 9 - 12	4	17.6 ± 4.3	21.6	304.7 ± 101.5	48.0 ± 25.2

In Figure VII, the total errors, computed by combining the records for retracing and cul-de-sac errors, given in columns 5 and 6 of Table XII, are presented graphically. Each line, as before, indicates by its length and position, one particular group, whose error score is specified by the figures above it. Thus group B 1-4, represented by the line four units long, extending from the first to the fourth guided trials, has a total error record of 134.4.

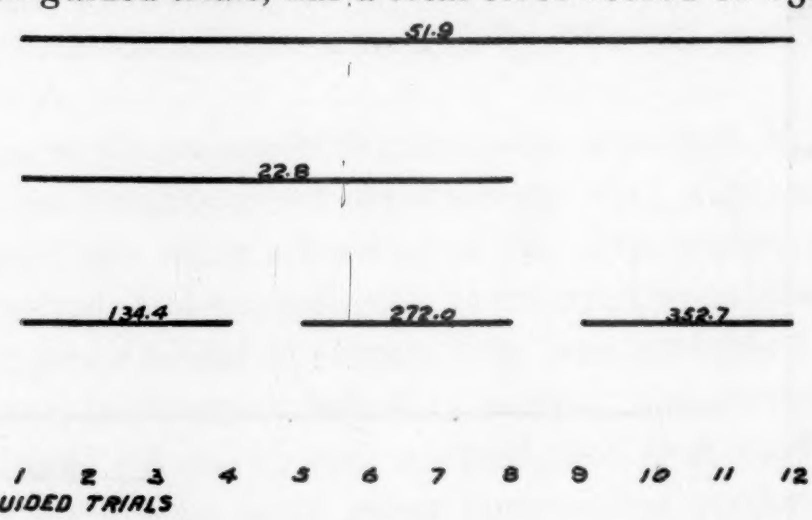


FIGURE VII
Combined Average Error Records of Guided Groups (Maze B)

The following conclusions are based upon the tabular and graphical presentations of the total trials:

1. Each amount and position of controlled trials introduced in the learning of this maze proved more effective than an equal number of corresponding uncontrolled trials. All groups attained a large degree of mastery over the problem during the period of the guidance.

2. The effectiveness of the guidance, for a given position, varies with amount. It increases in proportion to the number of controls given up to a certain point, beyond which additional amounts produce less beneficial results. Thus four controls, interpolated in the first, second, or third four trials, are less effective than eight, but more effective than twelve controls, initially introduced.

3. The effectiveness of the guidance, where the amount is kept constant, varies with position. Guidance interpolated at an early stage in the learning exerts a more beneficial influence than when introduced initially, but when it is interpolated at an advanced stage in the learning, there is a decrease in beneficial consequences. Thus the maximum effectiveness from four controls is attained when they are inserted during the fifth to eighth trials; when introduced initially, or interpolated during the ninth to twelfth trials, their value becomes decreasingly less.

The following are the outstanding features with respect to the error records given in Table XII and Figure VII.

1. Each number and position of guided trials introduced in the learning of maze B proved more effective than the same number of corresponding unguided trials. According to the criterion of error elimination, each controlled group attained a considerable degree of mastery over the problem during the period of the guidance.

2. As to the influence of amount in the initial position, the tendency is for the effectiveness of the guidance upon errors to increase proportionately with the number of controls given up to a certain point, and to decrease with larger numbers. Thus group B 1-4 exhibits decidedly increased error scores relative to group B 1-8, while the error record of the latter is reduced as compared with that of group B 1-12. It is impossible to judge whether this tendency would have remained constant if a larger number of groups had been employed, or whether the record for group B 1-12 is an exception, and the effectiveness of the guidance upon errors in maze B varies directly with amount, as was the tendency indicated in maze A.

3. As to the influence of position, when the amount is kept con-

stant, it is obvious that the effectiveness varies directly with proximity to the initial trials. Thus the error record for group B 1-4 is less than that for group B 5-8, which in turn is less than that for group B 9-12.

4. The guidance was more effective upon error elimination than upon trial reduction. From the percentages of saving which are specified in Table XIV, it is evident that the control produced approximately twice as much benefit in errors as in trials among the initially guided groups. The savings in retracing errors for the groups given interpolated guidance, however, represent slight exceptions to this tendency.

II. The second question is concerned with the differences in results obtained from the two mazes. To be sure, a fairly close correspondence in certain features is revealed by a comparison of the records. For example, the guidance was effective as a control upon the learning in maze B, beneficial result accruing from its introduction in every case. Moreover, the guidance in both mazes exercised a different degree of effect upon trials and errors. The effect of position upon both trial and error records, also, was consistently the same in maze B as it was in maze A. On the other hand, there are certain outstanding differences in results which may be summarized as follows:

1. The number and proportion of both types of error differ widely in the two mazes. Table XIII contrasts the total retracing and cul-de-sac errors required in the learning of each maze by groups given the number of controlled trials specified in column 1.

It is apparent that the cul-de-sac errors exceed the retracing errors in maze A, the proportion being approximately 2 : 1; whereas, in maze B, the reverse condition is true. The retracing errors greatly outnumber the cul-de-sac errors, the proportion being at least 4 : 1. The fact that these proportions remain quite consistent in the controlled as well as in the uncontrolled conditions of learning, is an indication that the difference is not a matter of guidance, but of maze structure.

2. The guidance produced a greater degree of benefit upon the learning of maze B than upon that of maze A. Within the limits of the amounts and positions investigated, each series of guided

TABLE XIII

Total Errors Under Similar Conditions of Learning in the Two Mazes

Controlled Trials	Maze A		Maze B	
	Retracings	Cul-de-sacs	Retracings	Cul-de-sacs
0	74.1	120.4	362.8	73.6
1 - 4	23.1	48.9	113.9	20.5
1 - 8	28.1	41.7	17.9	4.9
1 - 12	10.9	25.5	40.4	11.5
5 - 8	48.0	97.5	246.3	25.7
9 - 12	86.7	121.3	304.7	48.0

trials was more effective than the corresponding unguided trials in maze B, as indicated by both trial and error records. In maze A, on the contrary, certain of the same series were either negligible or deleterious in their effect, as indicated by the same criteria. Table XIV contrasts the percentage of saving and loss in total trials and errors, which accrued in the learning of each maze from the controls designated in column 1.

TABLE XIV

Saving and Loss in Trials and Errors Under Similar Conditions of Learning in the Two Mazes

Controlled Trials	Percentages of Saving and Loss					
	Maze A			Maze B		
	Trials	Retrac-ings	Cul-de-sacs	Trials	Retrac-ings	Cul-de-sacs
1 - 4	—1	69	59	31	69	72
1 - 8	5	62	65	44	95	93
1 - 12	—4	85	79	23	89	84
5 - 8	14	35	19	35	32	65
9 - 12	1	—17	—1	26	22	35

Obviously the savings in total trials produced by each number and position of controls introduced in maze B are markedly increased relative to the corresponding savings in maze A. Thus the group given four initial controls in maze B completed approximately one-third (31%) of the mastery of the maze during the period of the guidance. The corresponding group in maze A at-

tained practically no mastery over the maze during the guidance (—1%). In addition, the largest savings made by any control in maze A are 34% and 19% as compared with 44% and 35% in maze B.

The results produced by the guidance upon error elimination in maze B are not so dissimilar to the corresponding results in maze A. Savings in errors, however, accrue from the interpolation of four controls during the ninth to twelfth trials in maze B, as compared with losses in maze A; and the savings resulting from eight initial controls in maze B are in excess of savings accruing from any number or position of controls in maze A.

3. The influence exerted by varying amounts of guidance in the initial position, upon total trials, is somewhat different in the two mazes. In maze A, the optimum amount proved to be two guided trials, and additional amounts produced less beneficial results. In maze B, on the other hand, a small number of guided trials was not as beneficial as a larger number—the optimum amount proving to be eight—but increased amounts, again, produced less favorable results.

III. The third section is devoted to explanations of the differences in results obtained in the two mazes. The hypotheses advanced to account for the advantageous and disadvantageous effects of the guidance upon the learning of maze A are probably applicable to maze B, and the differences are undoubtedly a function of the structure and size of the second maze.

1. The predominance of retracing over cul-de-sac errors in maze B, which is the very reversal of conditions in maze A, is probably to be accounted for in the following manner: Whereas the number of cul-de-sacs is comparable in the two mazes, there being 15 in maze A and 12 in maze B, the number of sections composing the true pathway in the latter—namely, 35—is more than twice that of the former, namely, 16. This fact, taken in conjunction with the decidedly shorter length of the sections in maze B, indicates that a more refined unit of measurement was utilized in this problem. Obviously a return over the same distance of the true pathway involves many more errors in maze B, and partially explains the excessive amounts of retracings. In addition, a mode

of reaction was exhibited almost invariably in maze B, which was of rare occurrence in maze A. After familiarity with cul-de-sacs had been acquired, subjects were apt to infer that, whenever the stylus encountered the wall of a groove at the end of a section, an error had been committed. As a matter of fact, in the majority of cases, what was regarded as a cul-de-sac was in reality a section of the true pathway. When progress was prevented in one direction, the subjects, instead of persevering and investigating other forward directions, would resort to retracing movements. Such types of reaction were very persistent, and it was not uncommon for the entire pathway to be traversed many times during a single trial.

Moreover, a comparatively small number of cul-de-sac errors was required in the learning of maze B relative to that required in maze A. This is probably due to the fact that, so long as subjects moved the stylus in a given direction until they could advance no farther, cul-de-sac errors were impossible. In fact, entrance into a blind alley involved a deflection from the true pathway before the end of the section was reached. Provided straight forward movements the full length of each unit of the route were maintained, there were only two points at which choice was possible, and even here, the previous direction of movement determined the correct selection. Thus it was that the very structure of the maze provided minimum opportunity for cul-de-sac errors. In maze A, on the other hand, the same tendency shown by subjects to move the stylus in one direction as far as possible, inevitably led them into cul-de-sacs, which, it was mentioned before, were the last to be eliminated.

2. Guidance was more effective upon trial reduction and error elimination in maze B than it was in maze A. When introduced in the latter maze, as has been described above, it imparted an ideational knowledge of the true pathway which, in some form or other, was utilized to direct the subsequent learning. In maze B, the same type of benefit presumably accrued from the control, but, because of the intricate character of the pattern and the complicated series of movements involved, it is exceedingly improbable that any subject derived through guidance the clear, comprehen-

sive impression of the pathway which was acquired in maze A. On the other hand, a given amount of guidance wrought a greater degree of benefit upon the learning of maze B than upon that of maze A, due to the very complexity of the first mentioned problem. The more difficult the task to be mastered, the more efficacious the aid.

In addition to furnishing this ideational knowledge of the maze, the guidance induced the sensori-motor habit of executing, in a rhythmical manner, definite and precise movements, each terminated by contact with the resisting wall of the groove. The control, in fact, operated to enforce the natural tendency of each subject to continue moving in one direction as far as possible. This mode of reaction both prevented cul-de-sac errors, and overcame the inclination to retrace whenever an obstructing wall was encountered. Once this principle was grasped, or the habit established, the maze could be run perfectly, whereas a knowledge of the correct pathway in maze A did not necessarily denote a perfect performance. Thus there was in maze B a condensation of that portion of the learning which in maze A was characterized by the elimination of certain persistent cul-de-sac errors, and the result was a greater reduction in the number of trials and errors required to master the second maze.

3. The foregoing statements are probably explanatory, also, of the different effects upon total trials and errors obtained from varying amounts of guidance in the two mazes. Because of the greater complexity of maze B, the utmost benefit from the guidance could not be derived within a small number of controlled trials. Larger amounts were essential both to impart a clarified impression of the true pathway, and to establish on a firmer basis the sensori-motor types of reaction. After the optimum amount, which proved to be eight controlled trials, had been attained, however, additional numbers failed to produce as beneficial consequences, and presumably the detrimental effects of the guidance mentioned in the preceding chapter, were becoming manifest.

CHAPTER V

The Effect of Guidance upon Transfer

In addition to the main investigation reported in this research, a subsidiary experiment in transfer was undertaken. The purpose was to discover whether the control introduced in the learning of one maze had any effect upon the subsequent learning of a second maze.

We have presented in preceding chapters the results obtained from the learning of the two mazes by various groups of subjects under certain conditions. For the present experiment, the majority of those groups which mastered maze A returned twenty-four hours later and learned maze B. In a similar fashion most of the groups which had first learned maze B returned the following day at the same hour and mastered maze A. The second maze was learned in every instance by the normal undirected trial and error method. From a comparison of these results with those obtained in the mastery of each maze by groups which had had no previous experience, we may determine whether the transferred groups were at an advantage or a disadvantage because of their former maze experience, and whether the controlled groups were superior or inferior to the uncontrolled groups in this respect.

The comparative data may be analyzed in four sections, concerned respectively with the following questions: I. "What was the nature of the transfer in the normal groups?" II. "What were the comparative effects of controlled versus uncontrolled conditions of learning upon transfer?" III. "What was the relative effectiveness upon transfer of varying amounts and positions of control introduced in the learning of the first maze?" IV. "Does the effect of guidance upon transfer have any relationship to its effect upon learning?"

I. The first question may be answered by a comparison of the records for the transferred normal groups with those of the normal groups which had had no previous maze experience. Thus the

results in Maze B for the group which had formerly learned maze A unguided, and which is designated B (A-o), are contrasted with those of the normal group B; and in a similar manner, the results in maze A for the group which had first learned maze B unguided, A (B-o), are contrasted with those of the normal group A. These comparative data are given in Table XV, together with the percentages of saving and loss due to transfer.

TABLE XV

Trials and Errors in the Normal and Transferred Unguided Groups

Group	Trials	Errors		Perctg. of Saving and Loss		
		Retracings	Cul-de-sacs	Trials	Retracings	Cul-de-sacs
B	29.2 ± 11.6	362.8 ± 80.5	73.6 ± 44.7	..	..	..
B (A-o)	28.7 ± 15.9	256.1 ± 96.6	65.4 ± 39.1	2	29	11
A	28.8 ± 8.0	74.1 ± 25.3	120.4 ± 45.3	..	..	..
A (B-o)	26.8 ± 9.0	95.3 ± 20.7	160.2 ± 30.8	7	—29	—33

In addition, the learning curves of these groups are presented in Figure VIII. The total errors were utilized, since the same tendencies were exhibited in both retracings and cul-de-sac errors.

From these comparative data we may draw the following conclusions:

1. Notwithstanding the marked differences in size, structure, and pattern of the two mazes, the amount of the transfer, though small, is positive in character as measured by the criterion of trials. A positive transfer in trials obtains also in all the controlled groups (see Table XVI).

2. With respect to errors, a positive transfer is manifested when maze B was learned subsequent to maze A, this result being duplicated in six out of the eight controlled groups. A negative transfer, on the other hand, was obtained when the order of learning was reversed. Thus group A (B-o) required an increased number of errors to master maze A relative to that of the normal group in this maze. The appreciably increased error scores cannot be ascribed to exceptional individual records, because the variability was small, nor to chance, because the same tendency is exhibited in two of the three controlled groups.

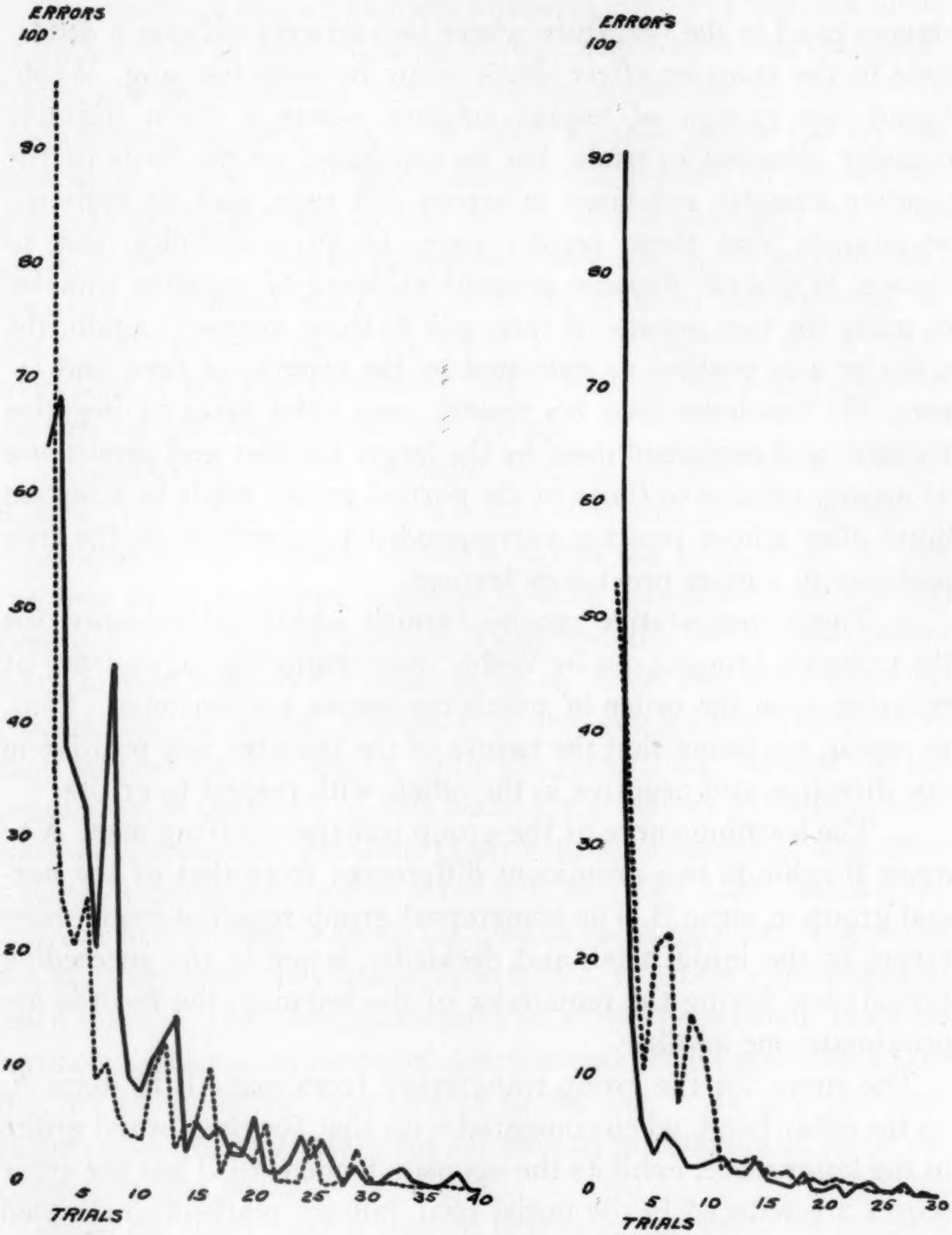


FIGURE VIII

Combined Average Errors
Group B -o ——
Group B (A-o) ....

Combined Average Errors
Group A -o ——
Group A (B-o) ....

We have illustrated in this case, therefore, a situation in which the learning of one maze is productive of a favorable effect upon trials, and a detrimental effect upon errors, in the learning of a second maze. Within the writer's knowledge there are but two in-

stances cited in the literature where two criteria indicate a difference in the transfer effect. Both occur in maze learning. Webb[1] found two groups of human subjects where a slight negative transfer obtained in trials, but he concluded on the basis of the positive transfer exhibited in errors and time, and an indiviual peculiarity, that these results were, in all probability, due to chance. Wiltbank[2] likewise presents evidence of negative transfer in trials for two groups of rats, and in these instances again, the transfer was positive as indicated by the criteria of time and errors. He concluded that his results were valid cases of negative transfer and explained them by the larger number and persistence of errors, relative to those of the normal group, made in a certain blind alley whose position corresponded to a section of the true pathway in a maze previously learned.

3. These comparative results furnish additional evidence for the principle brought out by Webb,[3] concerning the dependence of transfer upon the order in which the mazes are mastered. Thus, to repeat, we found that the nature of the transfer was positive in one direction and negative in the other, with respect to errors.

4. The learning curve of the group transferred from maze A to maze B exhibits two prominent differences from that of the normal group in maze B. The transferred group required many more errors in the initial trial, and decidedly fewer in the succeeding period; but during the remainder of the learning, the records approximate one another.

The curve for the group transferred from maze B to maze A, on the other hand, when compared with that for the normal group in the latter maze, exhibits the opposite tendencies. Thus the error scores are reduced in the initial trial, but are markedly increased over the normal series during the period of the learning immediately following, after which there is a close correspondence with the normal records.

[1] Webb: "Transfer of Training and Retroaction." *Psych. Rev. Mon. Suppl.*, Vol. 24 (1917), pp. 34-35.

[2] Wiltbank: "Transfer of Training in White Rats upon Various Series of Mazes." *Behav. Mon.* Vol 4 (1919), p. 18 ff.

[3] *Op. cit.*, p. 40 ff.

The results in neither of these instances conform with the locus of the transfer as determined by Webb,[4] who found that the transferred groups in general were saved the equivalent of the errors made during the first five trials; that is, they began the second problem at a level which approximated that reached by the normal group in the fifth trials. In our results, on the contrary, the locus of the transfer is confined to approximately the first ten trials, and the kind of transfer is a function of the order of the learning. In one group a positive effect is evident in the initial trial and a negative effect in the nine remaining trials, whereas the exact opposite obtains for the other transferred group.

The difference in the transfer effect of the two mazes is undoubtedly a function of their size and structure, and of the habits developed in the original problem. When the large maze A was the first to be mastered, subjects became accustomed to making long bold sweeping movements. Consequently, when these habits were carried over to the small maze B, where the units were decidedly reduced in size, this mode of reaction led them to traverse each section its full length, with the result that, because of the peculiarity in structure of this maze, the tendency to enter cul-de-sacs was minimized. Previous experience with retracing also operated to decrease this type of error. On the other hand, because the subjects had learned to locate the goal in the large maze A opposite the starting-point, they naturally inferred, when they attempted to learn maze B, that this goal would be similarly situated. Such an erroneous conception exercised a detrimental effect upon the learning, which, however, was limited to the first trial, and this fact is the probable explanation for the excessive amounts of error occurring in that period.

When the small maze B was the first to be mastered, the subjects became accustomed to executing an intricate series of short movements, each terminated by contact with the groove. This type of reaction, persisting in the subsequent attempts to learn the larger maze A, proved detrimental. For example, if the tendency to make short finely coördinated movements predominated,

[4] *Op. cit.*, p. 45 ff.

subjects were hesitant about making the long straight forward advances required, and were inclined to enter the first cul-de-sacs encountered. Consequently, they experienced unusual difficulty in eliminating the blind alleys numbered 3, 5, 13, 14 and 15 (see Figure I). On the other hand, if the tendency prevailed to move the stylus in one direction until further progress was prevented, despite the length of the section, subjects invariably entered cul-de-sacs 6, 8 and 10, and experienced greater difficulty in eliminating these than they otherwise would have.

Moreover, the difference in location of the goal in maze A probably operated to produce negative transfer. When maze B was the first to be mastered, subjects followed a somewhat circuitous route, discovering the location of the terminus proximate to the starting-point. In learning maze A subsequently, they naturally inferred that the goal here again would be situated near the starting-point. Consequently, when the vicinity of the cul-de-sacs 10 and 12 (Figure I) was reached, they almost invariably ceased further attempts in the forward direction. Confining their explorations to this region, they entered and re-entered these cul-de-sacs, then inaugurated retracing movements, and after experiencing unusual difficulty in locating the long forward run at the right side of the maze, were loth to venture in that direction. This attitude persisted for some time and apparently was but little affected by correct localizations of the goal obtained by chance. These features, therefore, partially account for the negative transfer in errors, while the mere fact of previous experience in a similar task explains the positive transfer obtained in trials.

II. The second question to be discussed is the comparative effect of controlled versus uncontrolled learning upon transfer. Inasmuch as it is a common observation that independent, self-initiated activity in seeking solutions and overcoming difficulties enables an individual to cope with future problematical situations more successfully, we might, with a certain degree of confidence, anticipate that the uncontrolled groups would be superior to the controlled groups in the learning of the second maze. Such, however, was not the case, as an examination of the data presented in Table XVI reveals.

TABLE XVI

Trials and Errors in the Transferred Controlled and Normal Groups

Group	Trials	Errors		Pctg. of Saving and Loss		
		Retracings	Cul-de-sacs	Trials	Retracings	Cul-de-sacs
B(A - 0)	28.7 ± 15.9	256.1 ± 96.6	65.4 ± 39.1	..	..	..
B(A 1- 2)	16.7 ± 7.7	179.1 ± 92.4	34.3 ± 24.8	42	30	48
B(A 3- 4)	26.9 ± 17.3	388.9 ± 152.6	74.6 ± 47.4	6	—52	—14
B(A 7- 8)	25.7 ± 10.4	275.7 ± 101.2	45.0 ± 39.4	10	— 8	31
B(A11-12)	26.8 ± 9.5	290.8 ± 108.4	52.1 ± 28.7	7	—14	20
B(A 1- 4)	22.7 ± 11.1	365.2 ± 167.2	84.4 ± 51.3	21	—43	—30
B(A 1- 8)	21.5 ± 10.4	264.2 ± 82.7	44.5 ± 32.3	25	— 3	32
B(A 1-12)	21.3 ± 9.5	266.4 ± 64.5	65.5 ± 35.7	26	— 4	0
B(A 1-16)	18.3 ± 12.0	203.3 ± 76.7	51.5 ± 49.8	36	21	21
A(B - 0)	26.8 ± 9.0	95.3 ± 51.7	160.2 ± 60.8	..	..	..
A(B 1- 4)	21.6 ± 9.1	83.7 ± 55.3	143.7 ± 47.8	19	12	10
A(B 1- 8)	18.3 ± 4.9	80.7 ± 41.3	126.3 ± 57.5	32	15	21
A(B 1-12)	16.3 ± 4.0	41.7 ± 33.5	78.0 ± 29.1	39	56	51

The table presents the records for all the transferred groups, controlled as well as uncontrolled, together with the percentages of saving and loss of the former with respect to the latter. Each transferred group is designated by the letter of the second maze learned, A or B, while in the parenthesis following is specified the amount and position of guidance introduced in the learning of the first maze. Thus B (A 1-4) denotes that group which, after having been controlled in the learning of maze A by four initial guided trials, subsequently mastered maze B.

The following are the outstanding features in these data:

1. All the controlled groups exhibit a greater positive transfer than do the uncontrolled groups with respect to trials. The savings relative to the trial record of group B (A -0) vary from 6% to 42%, and those of the controlled groups under the reverse order of transfer, relative to group A (B -0), vary from 19% to 39%.

2. With respect to errors, when the direction of transfer was from maze A to maze B, the controlled conditions of learning did not prove in every case as effective as the uncontrolled. In fact the guidance exercised a detrimental effect in transfer upon retracing errors with but two exceptions, although it exercised a favorable effect upon cul-de-sac errors, save for two exceptions.

When the order of mastery was from maze B to maze A, however, the controlled conditions of learning were consistently more effective upon both types of error than were the uncontrolled.

3. There is a tendency manifested in the data of the groups transferred from maze A to maze B for the guidance to exert a selective influence upon the two kinds of error. With but few exceptions, the control minimized the tendency to enter cul-de-sacs and increased the tendency to retrace.

4. No learning curves are included in this section, for they would supplement but little the facts adduced. The controlled groups were, in general, saved the equivalent of the errors made by the uncontrolled groups in the initial trial. Throughout the subsequent learning, they approximated more or less closely the records for the latter groups, but when the largest amounts of saving were exhibited, they maintained somewhat lower levels.

III. Having considered the general results for all transferred groups, we shall next examine the relative effect upon transfer of varying amounts and positions of control introduced in the learning of the first maze. The following tendencies are illustrated in the comparative data presented in Table XVI:

1. There is a tendency for the degree of transfer, when measured in terms of trials, to vary directly with the amount of initial guidance given in the first maze. Among the groups transferred from maze A to maze B, with the exception of group B (A 1-2), the greater the amount of initial guidance, the fewer the number of trials required to master the second maze. Thus the group given four initial controls exhibits a saving over the trial record of the transferred normal group of 21%; that given eight controls, of 25%; while the groups given twelve and sixteen controls exhibit savings of 26% and 36% respectively. Two initial controls introduced in the learning of maze A, however, were conducive to the greatest amount of benefit in the learning of maze B, as is evident in the saving of 42% for group B (A 1-2).

With the reverse order of transfer there is a marked tendency for the savings in trials to increase directly with the amount of initial guidance given in the first maze.

The same tendency is manifested without exception in errors,

when the direction of learning was from maze B to maze A. For the reverse direction of learning, the tendency is not so marked. It is evident, however, that the smallest and the largest amounts are conducive to the greatest transfer effect, medium amounts being productive of quite irregular effects. We may conclude, therefore, that the general rule is for the effectiveness of the control upon transfer to vary directly with the amount.

2. Any evidence as to the effect of varying positions of guidance upon transfer is limited to the results for one maze, and to the four groups given two controls at various stages in the learning process. The introduction of the control initially in the original problem mastered is more effective upon the subsequent problem than the interpolation of that same amount at any other period. Thus group B (A 1-2) exhibits greater savings in both trials and errors relative to the normal group, than do the groups given two controls at intermediate positions. Moreover, if group B (A 3-4) be excepted, as is justifiable because its excessive losses are due solely to one individual's record, we notice a tendency for the records of the two remaining groups to become increasingly inferior with respect to both trials and errors. If we eliminate one case, therefore, the rule is that the efficacy of the guidance upon transfer varies directly with its proximity to the initial trial.

IV. The fourth question to be discussed is the relationship between the efficacy of the guidance upon transfer and its efficacy upon learning. The necessary comparative data are presented in Table XVII, where the trials and errors in the learning are contrasted with the trials and errors in the transfer.

Inspection of these data reveals the fact that the amount and position of guidance which was most effective in learning was not that which was most effective in transfer. It is evident that the optimum amount in learning maze A, as measured by trials, was two controls inserted in the third and fourth trials, whereas the optimum amount in the transfer proved to be two controls inserted in the initial position. In the learning of maze B, eight initial controls were most effective upon both trials and errors, whereas in the transfer to maze A, twelve initial controls were productive of the maximal effectiveness.

TABLE XVII

Trials and Errors in the Learning of the First Maze and in the Transfer to the Second Maze

Group	Trials	Errors	Group	Trials	Errors
A - 0	28.8	194.5	B(A - 0)	28.7	321.5
A 1- 2	23.2	53.4	B(A 1- 2)	16.7	213.4
A 3- 4	19.1	164.5	B(A 3- 4)	26.9	463.5
A 7- 8	24.3	173.4	B(A 7- 8)	25.7	320.7
A11-12	30.1	273.8	B(A11-12)	26.8	342.9
A 1- 4	29.1	72.0	B(A 1- 4)	22.7	449.6
A 1- 8	27.5	69.8	B(A 1- 8)	21.5	308.7
A 1-12	29.9	36.4	B(A 1-12)	21.3	331.9
A 1-16	41.1	43.2	B(A 1-16)	18.3	254.8
B - 0	29.2	436.4	A(B - 0)	26.8	255.5
B 1- 4	20.3	134.4	A(B 1- 4)	21.6	227.4
B 1- 8	16.3	22.8	A(B 1- 8)	18.3	207.0
B 1-12	22.5	51.9	A(B 1-12)	16.3	119.7

By arranging in order of their effectiveness the actual numerical data for trials and errors obtained in both the learning and the transfer, and correlating these series of values, we may compare the effectiveness of the control irrespective of the interrelated factors of amount and position. Since nine groups were transferred from maze A to maze B, and four groups from maze B to maze A, 135 cases are represented in the first correlations and 60 in the second. The coefficients obtained by Spearman's rank method of correlation are presented in Table XVIII.

TABLE XVIII

Correlations Between Trials and Errors in Learning and Transfer

	A - B	B - A
Trials + Trials	.10	.25
Trials + Errors	.15	.19
Errors + Errors	.37	.56
Errors + Trials	.64	.51

In these data a definite relationship appears between the efficacy of the guidance as measured by *trials* in the learning, and its ef-

ficacy upon transfer, since the correlations, though comparatively small, are positive in both directions. So far as the efficacy of guidance upon *errors* in the learning is concerned, we find that the degree of relationship to its efficacy upon transfer is much higher for both mazes. In particular is this true for the relationship between errors in the learning and trials in the transfer, the coefficients being .64 and .51 for the two directions of transfer. Both because these coefficients are large enough and based upon a sufficient number of cases to possess statistical validity, and because the tendency is consistent throughout, we are justified in assuming that the groups which, due to the efficacy of the control required the least number of errors to learn the first maze, required the fewest trials and errors to master the second maze. This position is further supported by the fact that the controlled learning was more effective upon transfer than the uncontrolled. The outstanding difference in the two conditions which was common to both mazes was the fact that guidance invariably reduced errors in the learning.

Since the aspect of error elimination in the learning was conducive to the greatest effect upon transfer, any explanatory principle is undoubtedly to be sought in those factors which operated to reduce error. These were in the main the amount and position of the guidance, the rule being that the greater the amount of guidance given in the initial position, the greater was the reduction of errors. Consequently the more the control simplified the learning by eliminating the excessive exploratory activities during the initial stages, the greater was the transfer effect.

Several possible hypotheses for this fact suggest themselves, but because of the complexity of the situation and the lack of factual data, one has as much *a priori* plausibility as another. For example it is conceivable that subjects derived a general conceptual knowledge of the maze situation through guidance, which enabled them to discriminate between correct and incorrect responses, and that they carried over this discriminative capacity to the subsequent problem. Certain introspective data, at least, would seem to support this explanation. Again, it is possible that various habits and attitudes conducive to error elimination in the learning

were more deeply impressed in controlled conditions than in uncontrolled, and so functioned favorably in the subsequent problem.

Whatever the explanation may be, the fact remains that the conditions which were most effective upon the reduction of errors in the learning were most effective in the transfer. This feature in our experimental results is unique and should be recognized in the formulation of any theory of transfer. It cannot very readily be explained in terms of the theory postulated by Thorndike, according to which transfer occurs between two activities only when they possess identical neural elements or bonds of connection, the degree of transfer being proportional to the degree of identity of the bonds. In our experiments we should expect the greatest amount of transfer to obtain where the activities in the two situations exhibit the closest degree of correspondence. This condition is more nearly approximated in the free, unconstrained, trial and error method of mastering each maze, but we have demonstrated that under these very circumstances the least amount of transfer is obtained. When the activities are relatively the most divergent in the two situations, as in the case when the exploratory impulses were inhibited in the first maze and unrestrained in the second, the greatest amount of transfer was obtained.

Our results are relevant to the theory of generalization advocated by Judd, according to which it is the manner of instruction which determines the degree of transfer. He has emphasized this in the following quotation: "The first and most striking fact which is to be drawn from school experience is that one and the same subject-matter may be employed with one and the same student with wholly different results, according to the mode of presentation. If the lesson is presented in one fashion, it will produce a very large transfer; whereas if it is presented in an entirely different fashion, it will be utterly barren of results for other phases of mental life." [5]

It is possible that the phrase "mode of presentation," as used by Judd, refers primarily to the associative and assimilative processes thereby stimulated. In this narrow sense, it is doubtful

[5] Judd: "The Psychology of High School Subjects." 1915. p. 412.

whether our results are to be explained in terms of his theory. If, however, Judd means to include under this phrase any mode of learning induced by tuition, our data may be subsumed under his theory, for evidently the degree of transfer was a function of the way in which the first maze was mastered.

CHAPTER VI

Direct versus Indirect Effects of Guidance

The purpose of the present chapter is to determine whether any relations obtain between the direct effect of the guidance upon one problem, and its indirect effect upon that same problem through transfer. By direct effect of the guidance, we refer to the influence of the guidance introduced during the process of mastering a given maze, for example, A. By the indirect effect of the guidance, we mean the influence of the guidance apparent in the learning records for that same maze A, by groups which were given corresponding amounts of guidance in learning maze B, and which were subsequently transferred to maze A.

The comparative data may be found in Table XIX. The records of three groups in the learning of maze A are compared with the records of the three groups transferred to maze A, which were given equal amounts of control in learning maze B. The corresponding records for maze B are also presented.

TABLE XIX

Trials and Errors in the Learning of a Given Maze Versus Those in the Transfer to that Maze

Group	Trials	Errors	Group	Trials	Errors
A - 0	28.8	194.5	A	28.8	194.5
A 1 - 4	29.1	72.0	A(B1- 4)	21.6	227.4
A 1 - 8	27.5	69.8	A(B1- 8)	18.3	207.0
A 1 - 12	29.9	36.4	A(B1-12)	16.3	119.7
B - 0	29.2	436.4	B	29.2	436.4
B 1 - 4	20.3	134.4	B(A1- 4)	22.7	449.6
B 1 - 8	16.3	22.8	B(A1- 8)	21.5	308.7
B 1 - 12	22.5	51.9	B(A1-12)	21.3	331.9

From these data the following conclusions may be derived:

1. Guidance introduced directly in the learning is decidedly

more effective in reducing errors than guidance introduced indirectly through transfer. The total error scores in the learning are markedly reduced in all cases, whereas in the transfer they are increased in three groups, and when reduction occurs it is comparatively slight. The explanation for this feature is obviously the sheer physical fact of error prevention by the guidance.

2. The efficacy of varying amounts of guidance, directly introduced, corresponds exactly to its efficacy indirectly introduced through transfer, when it is measured in terms of errors. Thus, if the error scores of the controlled groups in learning and transfer be arranged in descending order, a perfect correlation exists between them for both mazes. This is but a further illustration of the fact brought out in the preceding chapter. That condition of learning which produced the minimum amount of errors was conducive to the maximum effect in transfer. Not only is this feature evident when the results in learning one maze are compared with those in transfer to the other maze, but also we find it illustrated when the results of direct and indirect guidance are compared in one maze.

3. Measured in terms of trials, the efficacy of direct versus indirect guidance is a function of the maze activities.

For maze A guidance indirectly introduced is the more effective. Thus each amount of the control produced lower trial records in the transfer to maze A than did the corresponding amounts of the control introduced in the learning of maze A by the experimenter. This fact is probably to be accounted for by the explanations hitherto given in discussions of the learning results for each maze. Thus because of the simplicity of maze A, large amounts of guidance produced attitudes such as over self-confidence and conviction of the ease of the problem, or passivity and too great dependence upon the experimenter, which proved detrimental in the learning as measured by trials. On the other hand, corresponding amounts of guidance introduced in maze B did not engender the same unfavorable attitudes because of the complexity of the problem and the amount to be learned. Consequently when groups which mastered maze B were transferred to maze A, they lacked

these attitudes whose effect was deleterious, and their performance was therefore superior with respect to trials.

For the other maze B, direct guidance is the more effective when measured in terms of trials, with but one exception. This fact is in accord with the assumption made in the preceding paragraph. If unfavorable attitudes were developed during the period of the guidance in maze A, we should expect their influence to be manifest in the subsequent transfer to maze B, and the trial records to be relatively increased over those in the learning of maze B. The one group which represents a slight exception to this statement is that given twelve controls in the learning of maze A, namely group B (A 1-12). The detrimental effects of too great an amount of guidance directly introduced in maze B were relatively larger than the detrimental effects carried over from the previous mastery of maze A.

4. The efficacy of varying amounts of guidance directly introduced, when measured in terms of trials, shows but slight correspondence with the efficacy of the same amounts indirectly introduced through transfer, in both mazes. This is to be expected because of the difference in the effects exerted by the same amounts of guidance upon trials in the learning of each maze, and because of the interaction of the factors mentioned above. Moreover, this fact is in accord with the data adduced in the preceding chapter, namely: the efficacy of the control upon trials in the learning bears but slight relationship to its efficacy upon transfer. The same feature is illustrated here, where the direct and indirect effects of the guidance are compared for a given maze.

CHAPTER VII

Summary and Results

This investigation has been limited to the effect of manual guidance as a control upon the learning of stylus mazes by human subjects. The evidence furnished by these experiments supports the position that such a control is beneficially effective. We may summarize our results in terms of the seven propositions outlined in Chapter I.

1. All the groups given initial guidance attained a certain degree of mastery over the problem during the control, since they required less errors and fewer subsequent unguided trials to learn the maze than the unguided groups.

The same statement is true of the groups given interpolated guidance at intermediate stages in learning maze B, and of all groups save two in learning maze A.

2. The amount of guidance in a given position which was productive of the optimum results was a function both of the maze and of the criteria employed.

In maze A there was a tendency for the effectiveness of the guidance in a given position, when measured in terms of trials, to vary inversely with the amount,—two controlled trials being productive of the maximum benefit. When measured in terms of errors, on the other hand, the efficacy of the guidance, with but two exceptions, tended to vary directly with the amount.

In maze B the effectiveness of the guidance, in a given position, upon both trials and errors increased in proportion to the amount up to a certain point, beyond which additional amounts produced less beneficial results. The optimum number proved to be eight initial controls.

3. The position of the guidance in the learning from which the optimum results accrued was the same in both mazes, but varied with the criteria employed.

Measured in terms of trials, a given amount of guidance intro-

duced at an early stage in the learning exerted a more beneficial influence than when introduced initially, but when it was interpolated at an advanced stage in the learning, there was a decrease in beneficial concequences.

Measured in terms of errors, however, the effectiveness of the guidance varied directly with proximity to the initial trials.

4. The efficacy of the guidance was a function of the maze activity. Without exception a given amount and position of guidance exerted a more beneficial effect upon the mastery of maze B than upon that of maze A.

5. The degree of transfer produced by the controlled type of learning was invariably greater than that produced by the uncontrolled type of learning, as indicated by trials. The same result was obtained with respect to errors in one order of transfer, but in the reverse order of transfer the guidance exercised a detrimental effect upon retracing errors.

A distinct relationship was exhibited between the amount and position of guidance which exerted the maximum effect upon errors in the learning, and the trials and errors made in the transfer. The greater the amount of guidance given in the initial position, and the greater the error reduction, the greater was the transfer effect.

6. Guidance introduced directly in the learning was more effective upon error elimination in both mazes than guidance indirectly introduced through transfer, but was less effective upon trial reduction in maze A.

The efficacy of varying amounts of guidance measured in terms of errors was the same irrespective of whether it was directly or indirectly introduced. Slight correspondence, however, was manifested between the direct and the indirect effects of varying amounts of guidance upon trials.

7. Throughout the preceding paragraphs we have emphasized the beneficial aspects of manual guidance as a control. The practical question which is of prime importance from the standpoint of education is the relative efficacy of controlled versus uncontrolled trials. Are given amounts and positions of guidance invariably more beneficial than corresponding amounts of unguided

trials, and did all the controlled groups learn the act with relatively less expenditure of effort than the uncontrolled groups? In other words, is this method of instruction always preferable to the normal undirected method?

Our results indicate that the *relative effectiveness* of guidance is a function of the maze activity.

In maze B, each amount and position of the control investigated proved more effective than the corresponding uncontrolled trials.

In maze A, each amount of guidance given in the initial position and interpolated in the early period of the learning was more effective only when measured by the criterion of total errors. According to the criterion of total trials, two controls given in any position during the first eight trials, and four controls given during the second four trials alone proved relatively more effective. When measured by the criterion of the errors required to complete the learning subsequent to the guidance, only one amount of control, namely two guided trials, given either initially or in the third and fourth trials, proved more beneficial than an equal number of unguided trials.

Although any broad generalization on the basis of these results would be unwarranted, we may conclude that the relative efficacy of this form of control is a function of the particular act of motor skill to be learned. In some problems it may exercise more beneficial results than self-directed trials in whatever amount and position it is introduced during the early period of the learning. In other problems its efficacy may be decidedly limited. In any event, experimentation alone can determine the specific amount and position of guidance which are conducive to more effective results than the normal unguided method of instruction.

Learning controlled by manual guidance constitutes a method which in the field of Comparative Psychology has been referred to as that of "putting the animal through the act to be learned."

Two variations of the method have been utilized: first, where the animal was bodily carried over the route of the act; and second, where the paw of the animal was put through the act. With respect to the former, Thorndike,[1] to whom credit must be given

[1] Thorndike: "Animal Intelligence" (1911), p. 101 ff.

for first investigating the problem, obtained only negative results. He dropped cats through a hole in the top of a puzzle-box, and although subsequently they opened the box, escaped, and were fed, they never of their own accord re-entered the box. Cole[2] and Hunter,[3] on the other hand, found that raccoons and rats did learn to climb to the top of a box and jump inside after they had been passively dropped through many times.

With respect to the second variation of this method, *i.e.,* when the paw of the animal was put through, Thorndike again obtained only negative results in the case of dogs and cats. He placed the animal in the puzzle-box, took hold of its paw, and with it pulled down the loop or pushed around the button necessary to open the door. No animal which failed to perform the act by its own unaided efforts ever learned by being put through. Moreover, the time consumed to learn the act with instruction was no shorter than the normal time without it, and save for one exception, the movement which the animal made to open the door was different from the movement which Thorndike had put it through. Cole, again, obtained positive results by this method. Not only was the learning process much more rapid in the case of raccoons which were put through the act a few times, but also animals which had failed of their own unaided efforts invariably succeeded immediately after being put through; and if there were two possible and equally difficult movements by which a given act could be performed, the tuition determined which one the raccoon adopted.

Although the contradictoriness of this evidence may be offset by such considerations as the difference in species and consequent difference in instinctive organization, the variation in the number of times guidance was given, and the number of animals employed in each experiment, we are forced to withhold any decision concerning the effectiveness of this method in animal learning.

The conditions in the second method mentioned above resemble our conditions inasmuch as both animal and human subjects were

[2] Cole: "Concerning the Intelligence of Raccoons." *Jour. Comp. Neur. and Psych.,* Vol. 17 (1907), p. 235 ff.

[3] Hunter: "A Note on the Behavior of the White Rat." *Jour. Animal Behav.,* Vol. 2 (1912), p. 137.

relatively passive—the movements being both initiated and directed by the experimenter. They differ from one another, however, in several respects. Neither the motives for learning, the nature of the problem, nor the knowledge of the problem were comparable in the two situations. The human subjects were deprived of vision; their attention was more readily controlled; and a certain amount of muscular innervation was required to hold the stylus. Finally, the human subjects inferred the purpose of the experiment, since they were requested to obtain all the benefit possible from the guidance.

Thorndike concluded that the inability of his animals to learn was due to the lack of a motor impulse which might be associated with the sensory stimulation, and assumed that if the animals had themselves initiated and directed their movements, learning would have occurred. Our results indicate, on the other hand, that in the case of human subjects, the absence of self-directed activity, and the substitution of extraneous direction under certain conditions, facilitated the learning. We would not maintain, however, that the learning occurred in spite of the absence of the motor impulse, but rather that it occurred because motor impulses were present in all cases. Granted that the subjects were comparatively passive during the control, they were nevertheless innervating the arm musculature continually in order to grasp the stylus. Moreover they were forced to adapt the posture of the arm to the series of movements inaugurated by the experimenter and the flexion and extension, the motion to right and left were necessarily self-initiated in part.

In addition to the presence of this motor impulse which was confined within a definite neural segment, we have reason to believe from the behavior of many subjects, that innervation of the gross bodily musculature was involved in the learning during guidance. Occasionally the head of a subject would be inclined in one direction and then in the other, corresponding to the succession of movements of the stylus, but most frequently the whole trunk would sway slightly back and forth, accompanying in a rhythmical way the series of movements inaugurated by the experimenter. By this means, presumably, a basis was afforded for the formation

of associations between sensory stimulations and responses, which functioned in the subsequent attempts at mastery.

Finally, since we employed human subjects exclusively, it is probable that the learning was not strictly confined to sensorimotor levels, but was partially in ideational terms. In this case there need be no question of the presence of the motor impulses. The articulatory mechanism alone would suffice and the incipient responses made to the sensory stimulations would serve to control the later learning.

The fact that this method was ineffective in some cases of animal learning is probably to be accounted for in other terms than that of the absence of the motor impulse. Presumably Thorndike would agree to our statements concerning the presence of the first-mentioned motor impulses in human subjects, and even grant that to a certain extent similar ones were functioning in the case of his dogs and cats, when their paws were guided through the correct act. The difference between the results for human and animal subjects may be due to the greater ease with which the attention of the former can be controlled, their knowledge of the purpose of the guidance, or the fact that their learning was in part upon an ideational level.

The results of our experiments have an obvious educational significance because of their bearing upon instructional technique. They also have theoretical significance because of their relation to the problem concerning the value of errors in the learning process. The assumption is generally made that errors are valuable in the acquisition of a novel adaptive response. The greater the exploratory activity and the more varied the forms of attack, the more rapidly will the solution be discovered. On the other hand, after the discovery of the successful act, the contention is advanced that errors are detrimental, inasmuch as they indicate impulsive tendencies which must be gradually eliminated.

Our results in one maze support the latter statement, since a large percentage of the errors made in the early process of fixation proved absolutely unnecessary, so far as the expenditure of effort and the rapidity of the learning were concerned. In the other maze, error prevention under very limited conditions alone was

more valuable than the making of errors and their subsequent rejection. In both problems a certain number of errors was required for mastery, however, a fact which indicates that the process of active inhibition is an essential element in most learning.

The assumption concerning the value of errors in the discovery of the solution of the problem was not tested in our investigation, because the period of the control was in no instance limited to the initial trial,—a certain portion of the fixation process being invariably included. The fact that eleven subjects out of the forty-five given initial guidance in the learning of maze B attained complete mastery over that problem during the period of the control, as indicated by the criterion of four correct successive trials, reveals the possibility of an act of skill being perfected when the solution is given, and the process of fixation occurs without error rejection.

When the value of errors in one problem is determined by the character of the response in a subsequent problem, our results support the conclusion that error prevention in any portion of the early stage of the learning is more valuable than the making of errors and their subsequent elimination.